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The research reported here involves upgrading the technology of the two telepathology workstations (TSS) previously built under this grant and the design and fabrication of the more compact PC Microscope (PCM). The TSS are being retrofitted to incorporate a diode array with a seven micrometer spacing. Enhancements have been made to the system software to simplify the user interface. The Luke/Mayo 1996 Telepathology Study concluded that the TSS does permit full-specimen, full color imaging that can be displayed on the computer screen, successfully transmitted for remote consultation by ISDN, and conveniently archived for future reference (Virtual Microscopy). For the PCM: (1) The PCI Stepper Motor Control Printed Circuit Board has been designed and is being fabricated. (2) Electronic imaging hardware has been designed and developed. (3) Two test enclosures for the video camera have been designed, developed and fabricated. (4) Fabrication drawings for and initial testing of the optical and mechanical systems have been completed. (5) The software logic and interface necessary for each of the user modes have been implemented. An extension of time is requested to complete all TSS retrofits, complete the PCM, and establish solid experiments using the TSS and the PCM. No additional funds are required.

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FOREWORD

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1. INTRODUCTION

This is the 1997 Fiscal Year Annual Report for grant DAMD17-94-J-4500 (Dual-Use Telemedicine Support System for Pathology) from the USAMRMC (U.S. Army Medical Research and Materiel Command) of Ft. Detrick, Maryland. The research reported here involves upgrading the technology of the two telepathology workstations (Figure 1) previously built under this grant and the design and fabrication of the more compact PC Microscope. This research was conducted in parallel with NIH (National Institutes of Health) grant 5 R44 GM44420-03 (Image Handling System for Pathology and Telepathology) and contract DAAH01-95-C-R209 (Workstation for Medical Images) issued by the U.S. Army Missile Command (Redstone Arsenal, Alabama) and sponsored by DARPA (Defense Advanced Research Projects Agency).

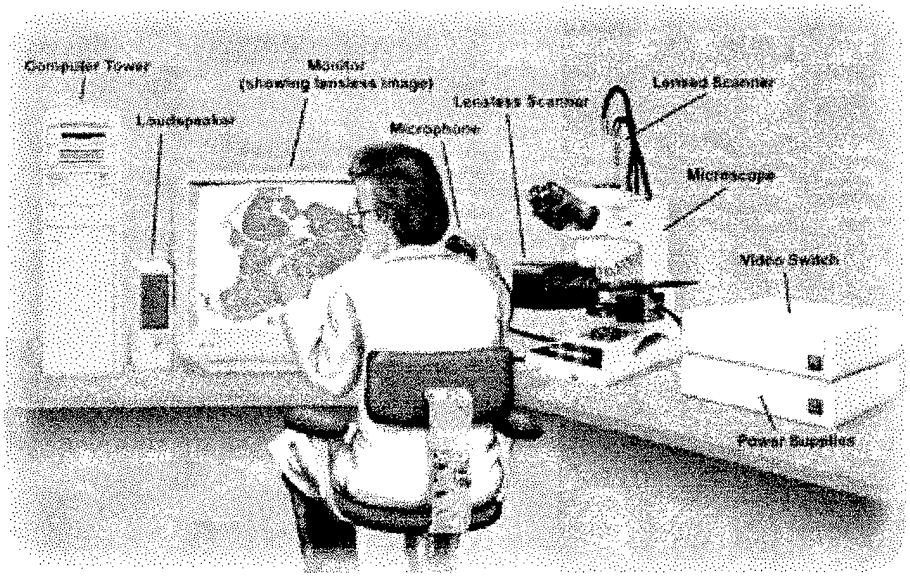


Fig. 1 - Kensal's Telepathology Support System (TSS).

The sections in this report are: (1) **Introduction**. (2) **TSS (Telepathology Support System) Retrofit** describes technology upgrades currently being made to the two existing Ft. Detrick workstations. (3) **PCM (Personal Computer Microscope)** describes the progress being made on the more compact, Macintosh telepathology workstation being built using Kensal's lensless/lensed technology. (4) **Field Trials** gives information on the first telepathology experiment using the Ft. Detrick workstations and plans for a future field trial. (5) **Virtual Microscopy** describes Kensal's self-running multimedia CD-ROM database of telepathology cases that were created using the Lensless/Lensed Imaging technique. (6) **Summary** includes positive and negative aspects of the project over the last year, recommendations for extending our project, and a conclusion.

2. TSS (TELEPATHOLOGY SUPPORT SYSTEM) RETROFIT

The TSS consists of standard, off-the-shelf components. A user interface permits production of a lensless "scout" image of the entire coverslip of a glass microscope slide. Using the scout image as a reference, areas of interest where finer detail is needed to complete the diagnosis can be magnified using traditional lensed microscopy.

This breakthrough is due to a patented development filed by Kendall Preston, Jr. (former President of Kensal Corporation) in the early 1980s wherein lenses are not required to generate a low-resolution magnified image. Instead, a line scan diode array (LSDA) is employed with the finest possible spacing between light detectors. Light pushing through the tissue sample produces a shadow detected by the LSDA. The precision of this shadow image depends only on the spacing of the diodes in the diode array and of course to their sensitivity to the impinging light and to the scan rate of the LSDA itself.

In late 1996, a dramatic improvement in low-resolution lensless microscopy was made possible by the introduction of the new EG&G Reticon RL4000P and the Kodak KLI-10203CA diode arrays which have diodes spaced on seven micrometer centers (Figure 2). Previous offerings from both manufacturers have diodes spaced on thirteen micrometer centers (Figure 3). The seven micrometer diode array makes it possible to digitize full coverslip images at 20 thousand picture points per square millimeter. With the thirteen micrometer diode array, only 6 thousand picture points per square millimeter was possible.

Currently, the two Ft. Detrick workstations are being retrofitted to incorporate the Kodak diode array with a seven micrometer spacing. The changes which are being made to upgrade the workstations to accommodate the new diode array include: Replacing the image acquisition card in the computer with the recently introduced Genesis card from Matrox. The Genesis card utilizes the PCI (Peripheral Component Interconnect) bus and has the capability of handling the higher data transfer rates imposed by the new diode array. The operating system of the computer has been upgraded to Windows NT v.4.0 to accommodate the Genesis card and improve system operation. The major modifications are to the lensless scanner and include replacing the Kodak KLI-4103 diode array with the KLI-10203 diode array and replacement of the Kodak KLI-4103EB evaluation electronics board with a custom electronics board (being designed and fabricated by Kline Research of Reseda, California). This custom electronics board has significant performance improvement over the Kodak unit. Some mechanical redesign of the scanner assembly is required to accommodate the KLI-10203 and the new electronics board.

Enhancements have been made to the system software to simplify the user interface and to make the workstation more "user friendly". These enhancements are a direct result of the 1996 Luke/Mayo Telepathology Study. (See Section 4.) Current capabilities of the TSS are explained fully in Appendix A, TSS User Manual.

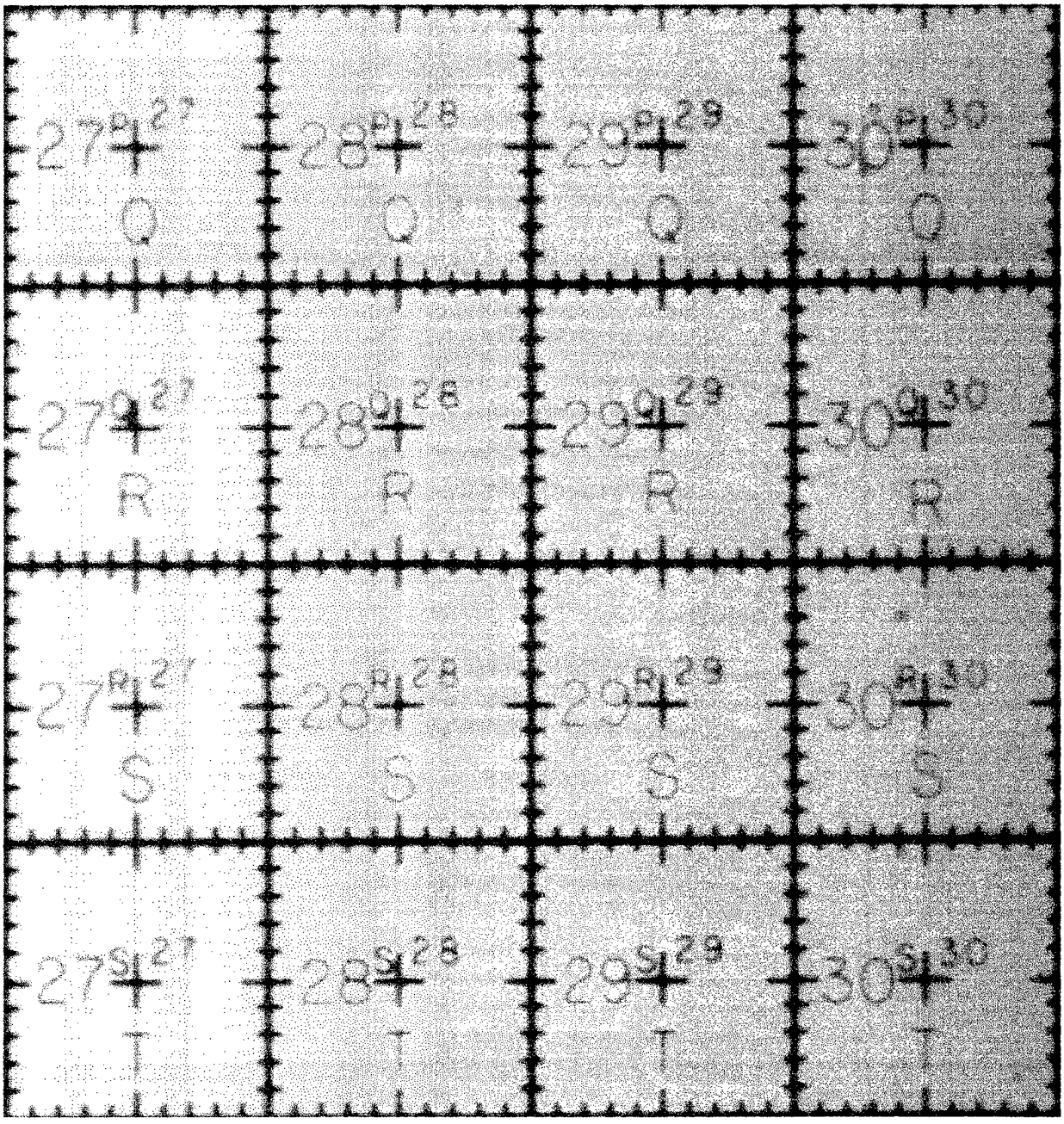


Fig. 2 - Seven micrometer lensless scan of a portion of a Lovins field finder.

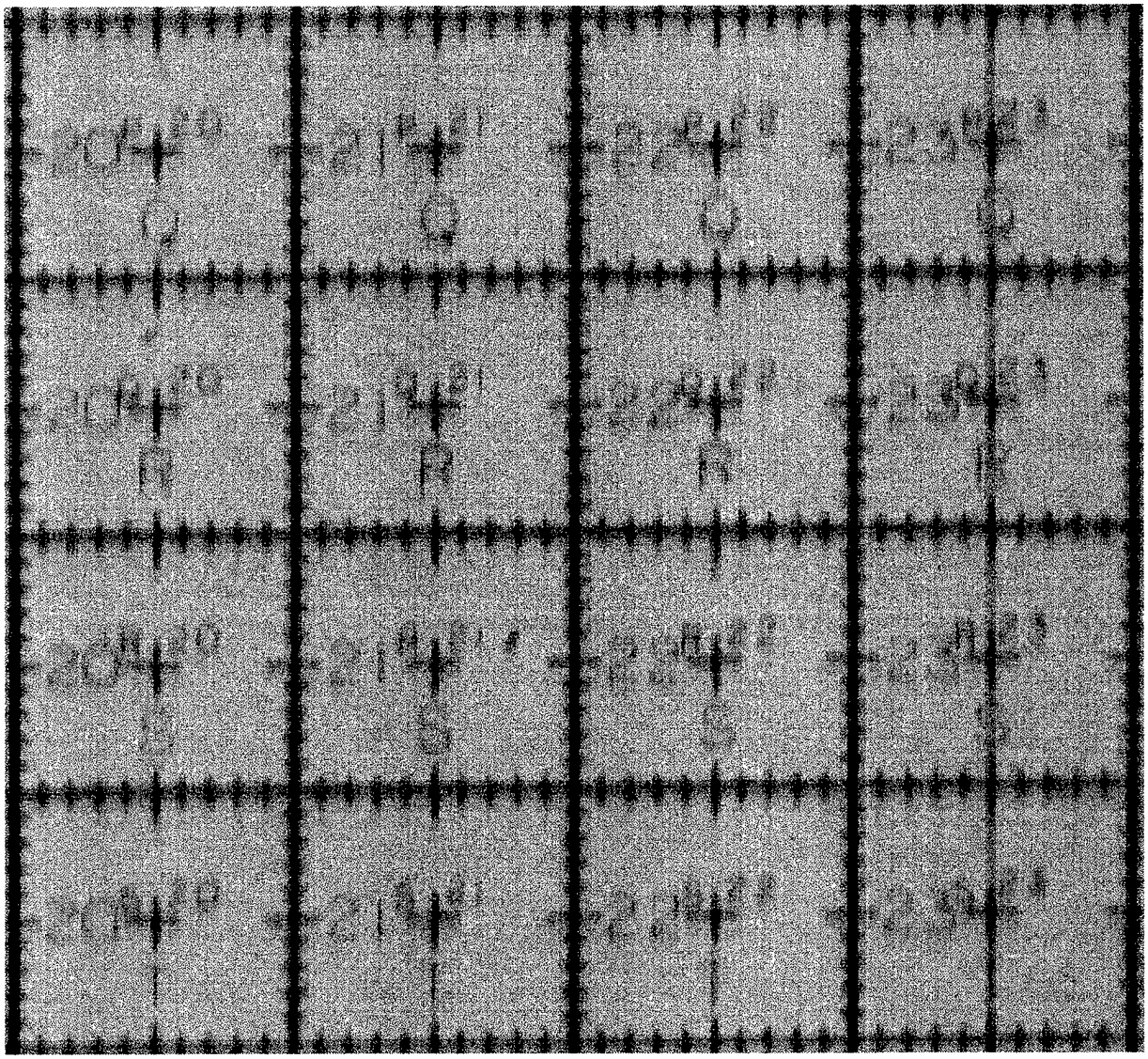


Fig. 3 - Thirteen micrometer lensless scan of a portion of a Lovins field finder.

3. PCM (PERSONAL COMPUTER MICROSCOPE)

The Windows NT-based TSS produced for the U.S. Army is composed of standard, off-the-shelf components. This system occupies an entire desktop. The more compact Macintosh-based PCM being produced for the U.S. Army has been reduced in size. See Figure 4. This extraordinarily simple and compact mechanism will provide a PC (Personal Computer), the lensless microscope, and a lensed microscope in a single housing.

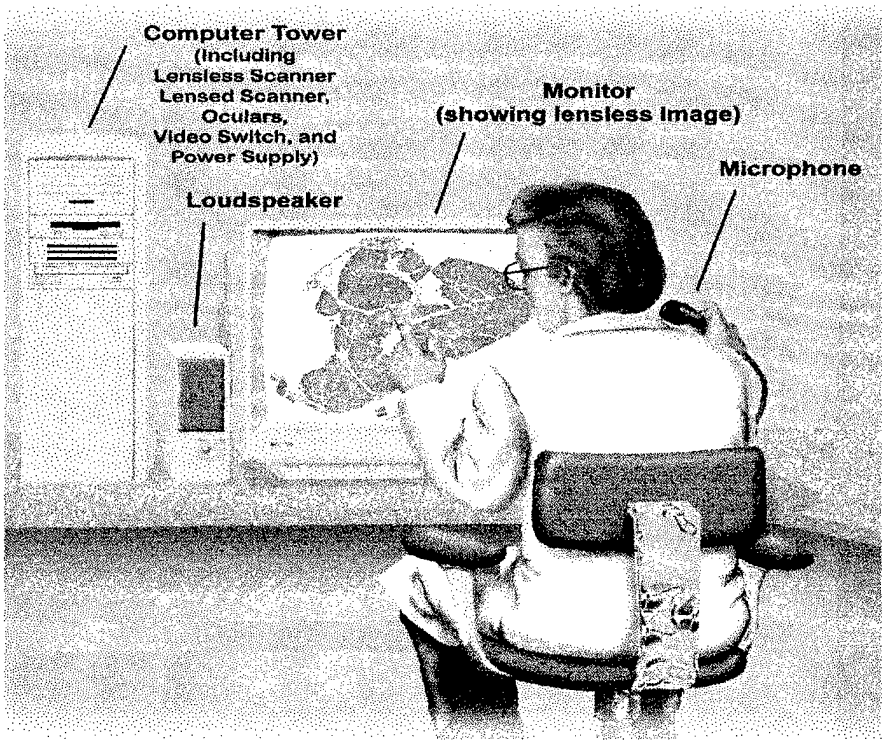


Fig. 4 - Kensal's Personal Computer Microscope (PCM).

In use, the PCM will receive the microscope slide through an insertion guide into a fixed, monolithic slide holder. A single traction roller will grab the slide, move it past the lensless scanner and seat it in the slide holder where it will be secured by both the traction roller and an associated pinch roller. Two moveable members, both of which have cutouts to accept the immobile, monolithic slide holder, would be used to position high-resolution, continuously-focusable optics if required. These members would consist of a horizontal yoke which would have ±1" travel so as to examine the full extent of the coverslip and the vertical platform with a ±1/2" travel to cover the 1" vertical dimension of the coverslip. Light will be delivered through a light-pipe illuminating a circular area approximately 2.5mm (0.1") in diameter and a lensed CCD scanner used if imaging at submicron resolution is required.

The PCI Stepper Motor Control PCB (Printed Circuit Board) for the Macintosh-based PCM has been designed and is being fabricated. This work included schematic capture, Altera HLD (High Level Design) entry and simulation, PCB layout, fabrication, assembly and design verification. We are proceeding with system integration of the Frame Capture Board (FCB), the Camera Head Electronics (CHE), and the Motor Control Board (MCB) into the PCM.

Electronic imaging hardware has been designed and developed to be used in the PCM. Two test enclosures for the PCM camera have been designed, developed and fabricated.

Fabrication drawings for and initial testing of the optical and mechanical systems have been completed. We are proceeding with construction of the optical and mechanical systems.

The logic and interface necessary for each of the user modes identified in the TPW design document have been implemented (See Appendix B.). For each of the modes, the preferences file was required and the dialog and interface needed for the preferences was developed. For the

transcription modes the voice dialog was made re-sizable, and the database entry dialog was executed.

4. FIELD TRIAL

In early 1996 a telepathology experiment began involving the Kensal Corporation (Tucson, AZ), the Mayo Clinic (Scottsdale, AZ) and the 56th Medical Group at Luke Air Force Base (Litchfield Park, AZ). The pathologists who participated in this experiment were Louis H. Weiland, MD and Kevin Leslie, MD from the Mayo Clinic, and Hermilando Payen, MD and Felix Mamani, MD from Luke AFB. A considerable amount of time was spent during the field trial dealing with hardware, software, and ISDN problems which became apparent from continued use of the equipment.

The following information is a result of the Luke/Mayo 1996 Telepathology Study.

A total of 42 cases were completed - 27 from Mayo and 15 from Luke. Five organ systems were represented in the field trial: Immune System, Breast, Skin, Excretory System, and Female Reproductive System. In 93 percent of the cases, diagnoses arrived at by using Kensal's TSS were the same as or similar to the original diagnoses arrived at by using traditional microscopy.

From the statistics provided to Kensal by our expert pathologists (See Appendix C.), on the average, 16 AOIs (Areas of Interest) were selected from each scout image and the diagnosis was determined by looking at 15 of those AOIs. The majority of diagnoses were arrived at while viewing a 40x or 20x high-magnification image.

Conclusions drawn from the Luke/Mayo 1996 Telepathology Study are as follows: (1) The TSS does permit full-specimen imaging that is now totally impossible using the traditional microscope. (2) Full-specimen digital images may be displayed on the computer screen in full color. (3) These digital images may be successfully transmitted for remote consultation by ISDN (Integrated Systems Digital Network). (4) Digitized pathology cases may be conveniently archived for future reference.

5. VIRTUAL MICROSCOPY

As part of our work on both PCM and TSS, a large image library has been produced. Our staff has modified the software package called "Virtual Microscopy".

Virtual Microscopy is a self running multimedia CD-ROM database containing telepathology cases, created using the L/L (Lensless/Lensed) Imaging technique. Each case includes a Lensless, low resolution scout image, several regions of interest recorded by lensed microscopy (referred to as High Magnification image or "HM"), and recorded-voice diagnosis.

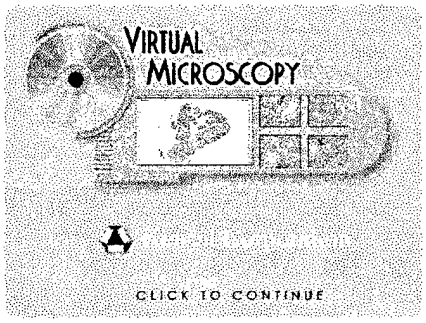


Fig. 5 - Virtual Microscopy's Title Screen.

5.1 Mannequin Search

Pathology cases are accessed interactively by selecting call-outs on a mannequin. Rotating or changing the gender of the mannequin allows the user to access all pathology cases.

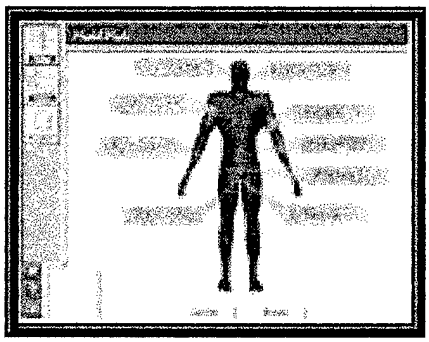


Fig. 6 - Virtual Microscopy's Mannequin Search screen.

5.2 Index Search

Cases are listed alphabetically by tissue or organ system in "Index" search mode. Selecting a case displays thumbnails of all images and voice playback options for that case. Clicking on a thumbnail image displays the selected scout or HM at full resolution.

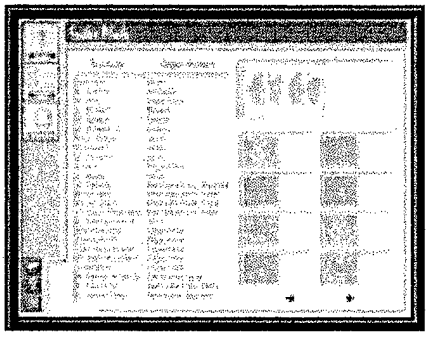


Fig. 7 - Virtual Microscopy's Index Mode screen.

5.3 Scout View

When a case has been selected with the interactive mannequin or with the indexed listing, the case scout image is displayed. In this display, selected regions of interest are outlined in black. Clicking on a region of interest opens the corresponding HM. Pressing the playback button in this display starts the voice-over for the scout image.

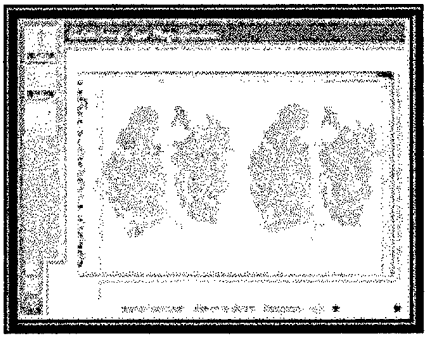


Fig. 8 - Virtual Microscopy's Scout Image Low Magnification screen.

5.4 Lensed High Magnification

Selecting a region of interest on the scout image, or selecting the HM thumbnail in the indexed listing displays the corresponding lensed, HM image. The HM image can be expanded to full resolution, panned, or the HM's voice-over can be played back.

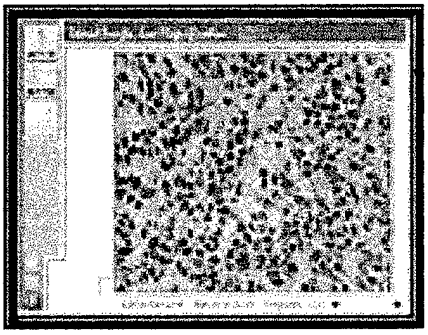


Fig. 9 - Virtual Microscopy's Lensed Image High Magnification screen.

5.5 Slide Show

The 'Slide Show' screen lists the images in the current carousel and allows the user to view, edit, or play the carousel contents.

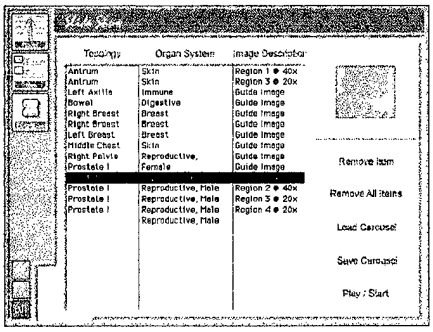


Fig. 10 - Virtual Microscopy's Slide Show assembly screen.

The 'Playback' screen allows the user to navigate through the selected images, zoom and pan on an image, or play the voice diagnosis. At any time the user can stop the playback and return to the 'Slide Show' screen.

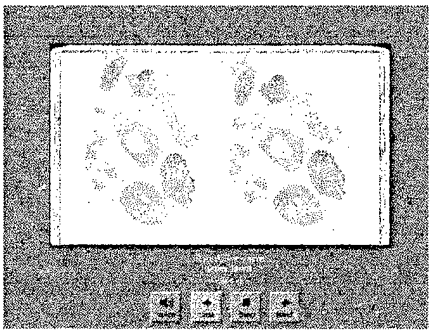


Fig. 11 - Virtual Microscopy's Slide Show playback screen.

"Virtual Microscopy" will be an effective educational tool in that it simulates the operation of using lensless and lensed images. It was designed in a way that course material may be distributed inexpensively by CD-ROM or over the Internet.

6. SUMMARY

This section includes the positive and negative aspects of this project over the last year, a request for extending this project, and a conclusion.

6.1 Positive Aspects of Grant Research in FY 96-97

The rapid prototype workstations (TSS) proved that lensless imaging is an effective tool for the pathologist. As a result of this telepathology study, "Virtual Microscopy" was created (Section 5) and the need for software enhancements was realized and implemented (Section 2).

The TSS User Manual has been completed and updated to include all retrofits to date. An installation guide is now being written by Kensal staff.

Work is proceeding on schedule for the PCM. Delivery date of the finished product is expected by the end of December 1997.

In June 1997, Kensal attended the DARPA Workshop held in Tucson, Arizona. Kensal's presentation was received with much excitement and enthusiasm. Dr. Richard Satava was especially impressed with Kensal's "Virtual Microscopy" and the educational possibilities it holds.

In August 1997, Kensal staff was invited to Ft. Detrick, Maryland to discuss our telepathology project. General Zajtchuk expressed interest in having Telemedicine Research Laboratory involved in the next telepathology experiment using Kensal's workstations.

In September 1997, Kensal's President and CEO, Diane Conti, visited AFIP (Armed Forces Institute of Pathology) and Harvard Medical School. Both AFIP and Harvard Medical School were extremely enthusiastic about our project and expressed interest in being chosen for future telepathology experiments.

6.2 Negative Aspects of Grant Research in FY 96-97

Due to problems with hardware, software and ISDN hook-up, the Luke/Mayo 1996 Telepathology Study was unable to achieve all that was initially planned. Time did not allow for the actual glass microscope slide to be reviewed by the remote user so we referred back to the patient file for the original diagnosis of each slide which was done by traditional microscopy. However, the experiment did prove successful in that we were able to establish the fact that the TSS is a viable diagnostic tool for the pathologist.

Problems with Matrox shipping new products has caused a delay in retrofitting the TSS workstation since the second quarter of 1997. The current ship date is the end of October 1997. We have on loan from Matrox a demonstration board that will allow us to proceed with the retrofit until the boards on order become available.

6.3 Extending Our Research

Under grant DAMD17-94-J-4500 from the U.S. Army Medical Research and Materiel Command (USAMRMC, Ft. Detrick, Maryland) and contract DAAH01-95-C-R209 from the Redstone Arsenal (Redstone, Alabama), the Kensal Corporation has built three lensless/lensed TSS workstations - two for Ft. Detrick and one for Redstone Arsenal and designed and initiated fabrication of two PCMs.

In September 1997, Kensal Corporation received permission from Redstone Arsenal to extend the completion date of that contract to June 30, 1998. This will allow us to retrofit the one TSS workstation that has been built under DAAH01-95-C-R209 for Redstone Arsenal into a revolutionary new instrument that will combine recent advancements in diode array scanning with the existing instrument that was completed during late 1996 and will make it compatible with the two Ft. Detrick workstations now undergoing the same retrofit. It will also allow sufficient time to complete and test the PCM.

As this contract works in conjunction with the Detrick grant, we request an extension of time for our USAMRMC grant to June 30, 1998. This time extension is due in large part because of delays in delivery of components (see Section 6.2). This would allow us to complete all retrofits, complete the two PCMs, and establish a solid experiment using all three retrofitted TSS workstations and the two PCMs. No additional funds are required.

6.4 CONCLUSION

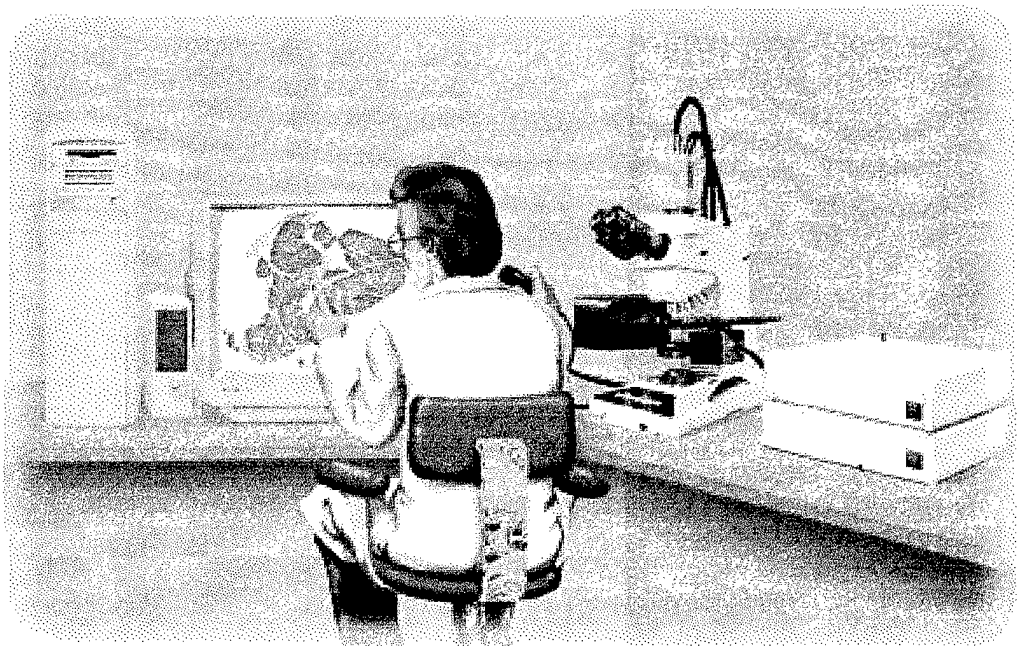
Proving that lensless microscopy does work with the TSS, progress made on the PCM, and creating "Virtual Microscopy" have been exciting developments for FY 96-97. Testing the retrofitted TSS, successfully completing our first transmission on PCM, and fully developing "Virtual Microscopy" are a few of the things we are looking forward to in FY 97-98.

But, as the old saying goes, "with the good comes the bad". That has certainly been the case at Kensal this year. We were all deeply saddened by the death of Kendall Preston, Jr., President of Kensal Corporation, and inventor of lensless microscopy. Although this loss has been great, Kensal staff is all the more dedicated to seeing this project through to its successful completion. Because of his expert planning and leadership, Kensal staff can confidently complete this project's final phase and continue to develop lensless microscopy into a viable replacement for traditional microscopy.

APPENDIX A

TSS USER MANUAL

MULTI-USE
TELEMEDICINE SUPPORT SYSTEM
FOR PATHOLOGY
(TSS)



USER MANUAL

Kensal Corporation
Tucson, AZ

USER MANUAL
FOR THE
MULTI-USE TELEMEDICINE SUPPORT SYSTEM FOR PATHOLOGY
(TSS)

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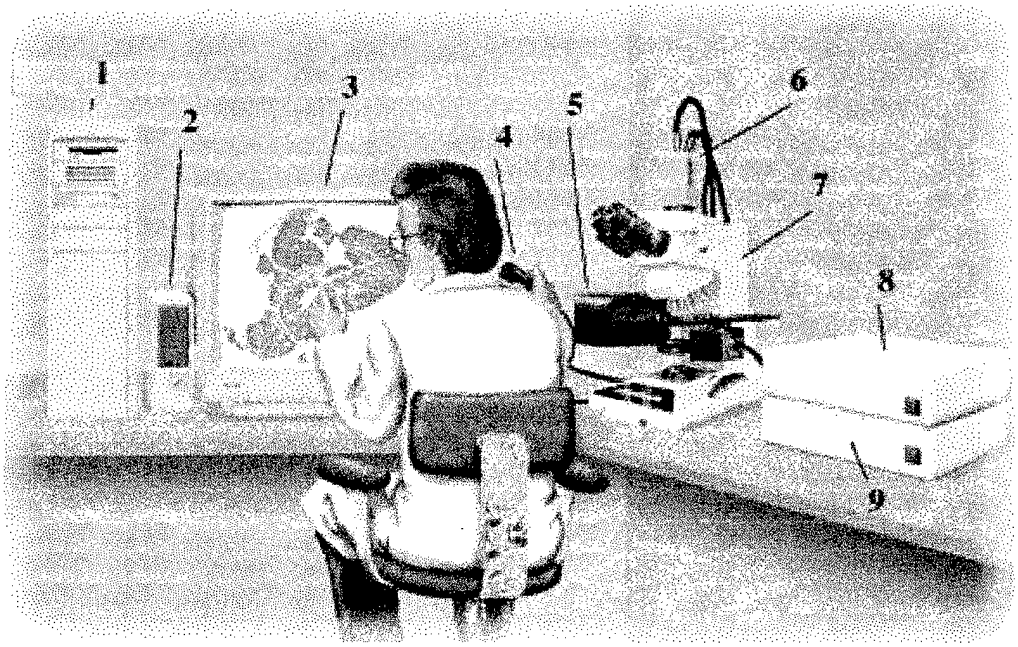
USER MANUAL
FOR THE
MULTI-USE TELEMEDICINE SUPPORT SYSTEM FOR PATHOLOGY
(TSS)

1. INTRODUCTION

Welcome to the Multi-Use Telemedicine Support System for Pathology (TSS). The TSS is a medical imaging telecommunications system that aids the pathologist in viewing glass microscope slides during routine pathological examinations, and allows for sending and receiving images and voice files.

The TSS User Manual is designed to serve as a reference tool for users who are unfamiliar with the standard operations of the system. It provides the user with step-by-step instructions on how to operate this workstation. This is a user manual, NOT a technical manual. For technical information, please contact Kensal Corporation.

1.1 Workstation Components



1 - Computer Tower
2 - Loudspeaker
3 - Touchscreen Monitor
4 - Microphone
5 - Lensless Scanner
6 - CCD Camera
7 - Microscope
8 - Power Supplies
9 - Motion Controller

2. GETTING STARTED

The TSS consists of identical workstations that capture, display, store, retrieve and communicate pathology images over ISDN (Integrated Services Digital Network) lines. For ease of use, all modes of operation are accessible by simply touching the appropriate buttons on the touchscreen with your finger-tip. A white arrow appears on the screen indicating where you have touched last. If you drag your finger across the screen, the arrow will follow your movement. Releasing pressure on the screen will activate the button underneath the arrow.

This instrument is designed for use on glass microscope slides with coverslips only. Scanning any wet or non-solid medium can result in serious damage to the workstation.

2.1 Turning On Workstation

To start the workstation, push the switch on the CPU to the "On" position. After a few seconds, the loader screen with the operating system will appear.

2.2 Choosing an Operating System

Touch ***Windows NT Workstation*** and press "Enter" on the computer keyboard to choose the operating system. This is the first default option and will automatically connect after 30 seconds. Wait for the *Windows NT Welcome* Screen to appear.

2.3 Logging On

When prompted, press "Ctrl + Alt + Del" simultaneously on the computer keyboard to log on to the system. A *Welcome* dialogue box will appear asking for the username and the password. (NOTE: A Kensal technician will set up your username and password before you begin using this system.) After typing in your username and password, touch ***OK***. After a few seconds the *Main TSS Window* will appear. **The TSS is now ready to conduct examinations in either the Local or the Remote Mode.**

3. LOCAL MODE

Local Mode is used when the operator is 1) making an examination of a glass microscope slide for use at his/her location, 2) making a scout image to transmit to a remote workstation, and 3) recalling stored images for examination or comparison.

The operator will have the option of ending the session at any time by selecting ***Home***, which initiates a return to the *Main TSS Window*. From the main window, press ***Exit*** to prepare the system for shut down.

The operator may press ***Help*** to access the on-line Help Index. By touching any of the green, underlined commands, the corresponding help file will appear on screen. To return to the help index, touch ***Back***, found on the gray menu bar. Browse the help application by pressing on the ***Search*** option. To exit Help, touch ***File*** on the white menu bar, and when the menu drops down, touch ***Exit*** to return to the *Main TSS Window.*

3.1 Initiating Local Mode

Touch ***Single Station New Image Send and View.*** This will initiate the Local Mode.

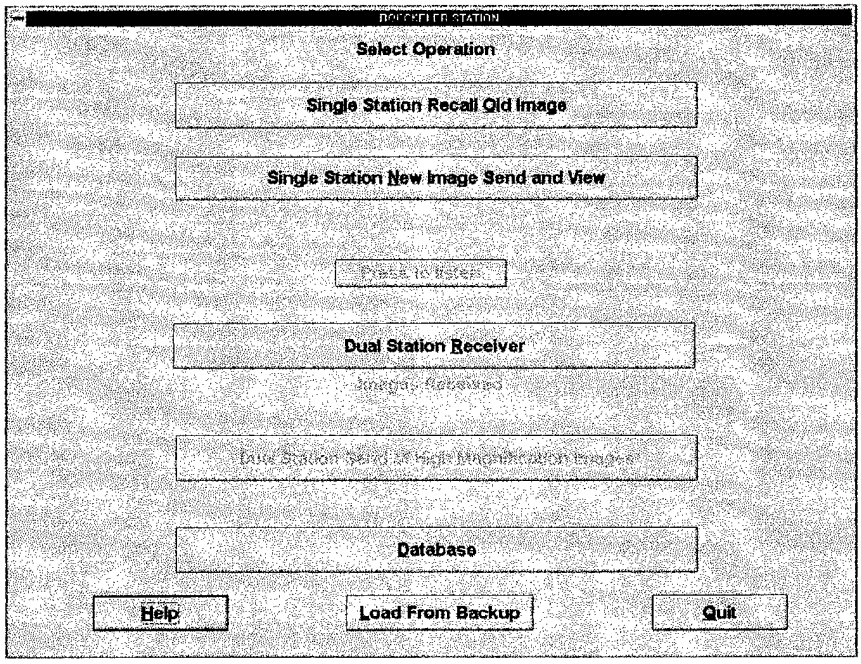


Fig. 2 - The Main TSS window.

3.2 Entering Slide Number

Enter the six digit accession number of the microscope slide by using the numerical keypad located on the touchscreen. If a mistake is made, touch ***Clear*** and reenter the numbers. If the number was entered correctly, touch ***OK***. The *Load Slide Carrier* window will appear.

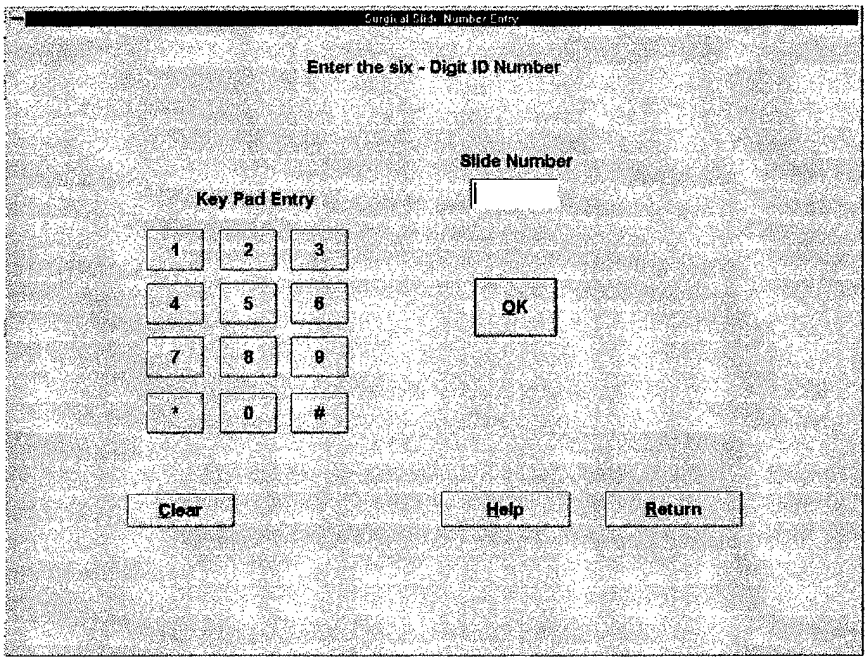


Fig. 3 - The Surgical Slide Number Entry screen.

3.3 Loading a Microscope Slide

Clean the microscope slide of all fingerprints and markings as these may affect the appearance of the scanned image. Place the microscope slide, cover glass facing up, with the labeled end toward the back of the microscope. Guide the glass slide into position and secure it in place with the specimen holder, as shown in Figure 4 below.

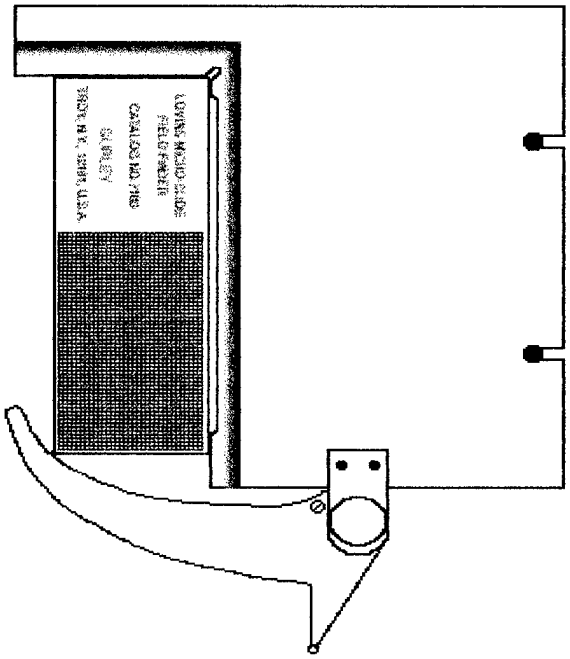


Fig. 4 - Drawing depicting correct slide orientation and security by the specimen holder.

Once the slide is securely in place, choose which stain has been applied to the tissue. The correct slide number should appear in the upper right corner of the screen. Touch ***O K***. The microscope will initiate the scanning to produce a scout image of the slide.

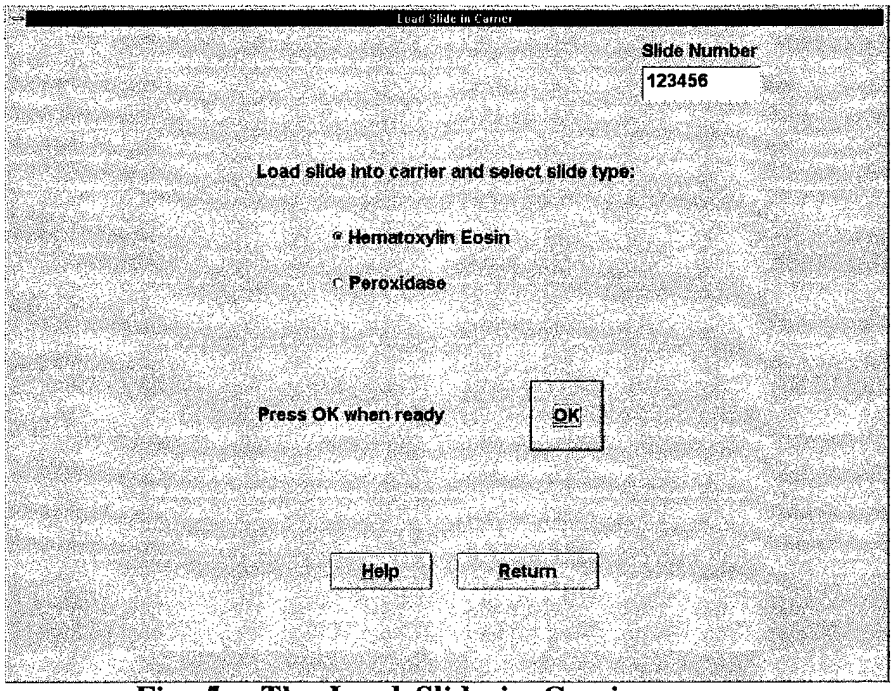


Fig. 5 - The Load Slide in Carrier screen.

3.4 Viewing the Scout Image

The *Scout Image Display, Select HI-MAG* screen will appear displaying the scout image in the main window. The scout image is automatically saved when the image is loaded and focused automatically. There is no way to further adjust the focus of a scout image. A thumbnail will appear in the upper right corner of the screen showing the current location on the scout image in a green box. The operator has the ability to pan and scroll around the image through "jumping," a process which will move any touched region of the image to the center of the screen.

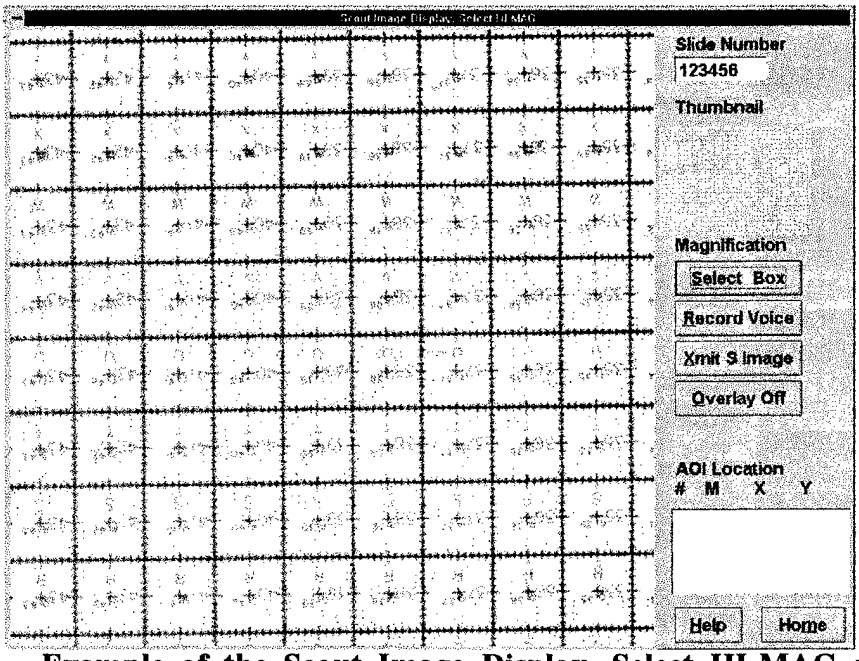


Fig. 6 - Example of the Scout Image Display, Select HI-MAG screen.

The user may record any comments about the scout image by pressing ***Record Voice.*** A dialogue box will appear, making sure that the user is ready to record. Upon pressing ***Yes,*** a new dialogue box will appear, immediately initiating the recording process. When finished recording the message, touch ***Stop***. To replace the message, touch ***Restart*** and begin again. When finished, touch ***Stop*** and then touch ***Exit.***

3.5 Selecting Locations for Higher Magnification

While viewing the scout image, the operator can identify areas of interest (AOI) for which a high magnification image is desired. To select locations for high-magnification examination, touch ***Select Box***. This will bring up a dialogue box containing buttons for magnifications ranging from 2x to 40x.

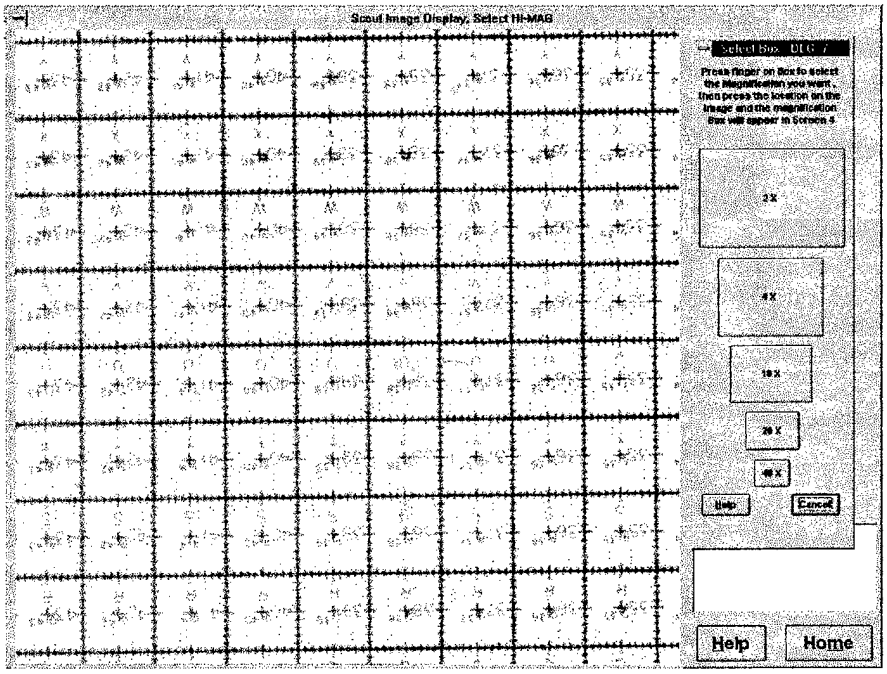


Fig. 7 - Example of the dialogue box used to highlight AOI's and their subsequent magnifications.

Touch the magnification desired for an area of interest. A small, square, black marker will appear on the screen in place of the white arrow marker. Touch the location on the scout image to be magnified. A black box surrounding the area to be magnified will appear. If the box needs to be moved to a more specific location, use the arrow keys on the keyboard to move left, right, up, or down. **Once the screen is touched again, the AOI box will turn green and become fixed in that location.** The size of the box surrounding the AOI will correlate with the desired magnification: a large box represents a low magnification while a small box represents a high magnification. In addition, the coordinates and the chosen magnification of the area will appear in the AOI Location Box in the lower right corner of the screen.

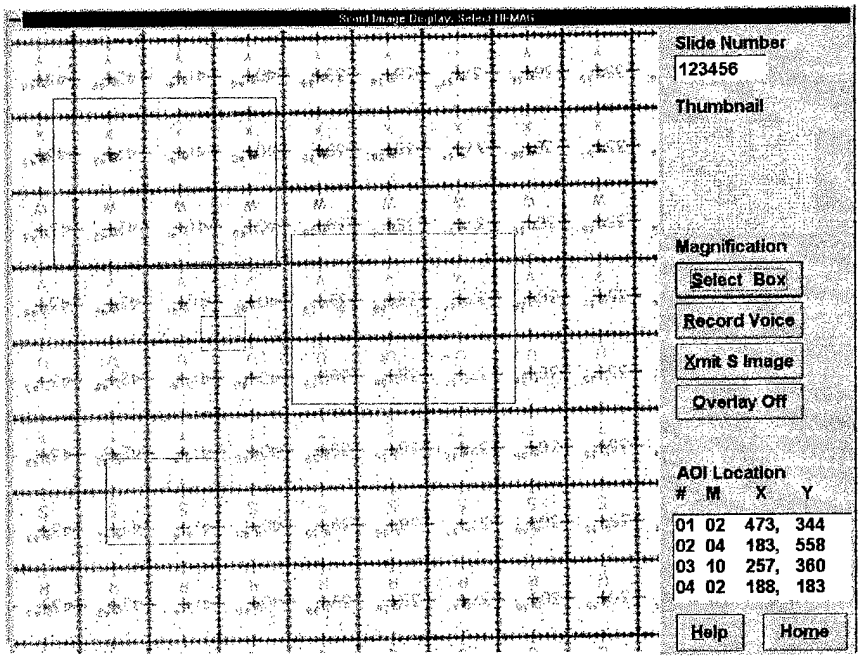


Fig. 8 - Example of a scout image with selected regions for higher magnification.

The operator may continue to select locations and magnifications as desired. Touching the ***Overlay*** button will clear the scout image of green boxes for ease of viewing. Touching ***Overlay*** again will bring the green boxes back on the screen.

3.6 Viewing and Saving High Magnification Images

When all desired locations have been selected, touch inside of any green box to retrieve the corresponding high magnification image. The system will switch from the lensless scanner to the lensed microscope. The computer will move the slide to the desired X,Y location, rotate the objective turret to the proper magnification for the location selected, adjust the condenser for the corresponding objective, adjust the illumination level, and display the high-magnification image on the monitor in real time. Unlike the lensless scans, the microscope showing the higher magnification images does not automatically adjust the focus.

The *High Magnification Image Window* will appear with the first selected high magnification image in the large window. A thumbnail of the scout image will appear in the upper right corner showing, with cross-hairs, the current location on the slide. The operator may use the touchscreen display to change objectives, adjust the focus, and examine the slide under the microscope using the "jump" method mentioned earlier. If the light needs additional adjusting, it may be helpful to turn the apperture at the center, base of the microscope. Open or close the apperture to let in the appropriate amount of light.

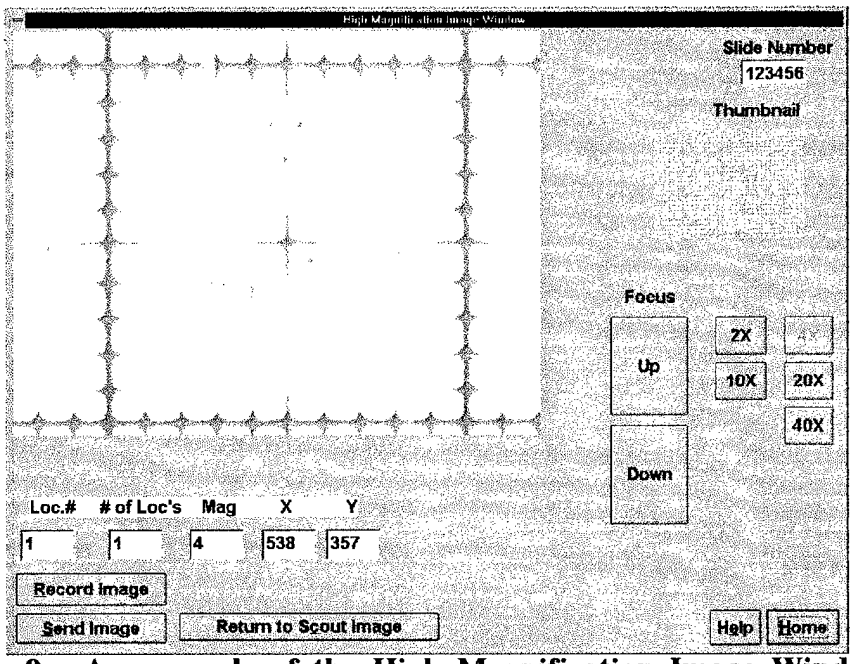


Fig. 9 - An example of the High Magnification Image Window.

Once an AOI, magnification, and focus have been set, the operator may save the image by touching ***Record Image***. The computer will compress the image using a JPEG format and store the image with a file name of the microscope slide identification number and an extension in numerical order. The computer will also store the date, time, and location of capture.

The option to record a verbal message will appear when saving a high-magnification image. To record a message, touch ***Yes***. Recording will start automatically with the elapsed time appearing. When finished recording the message, touch ***Stop***. To replace the message, touch ***Restart*** and begin again. When finished, touch ***Stop*** and then touch ***Exit.***

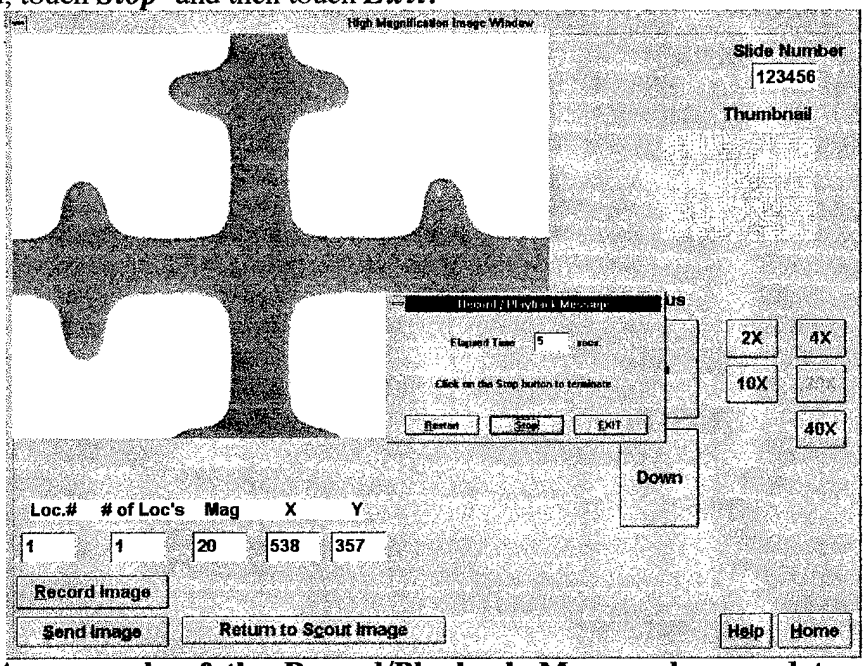


Fig. 10 - An example of the Record/Playback Message box used to record and playback comments about the image being displayed.

To move to the next X,Y location, the user must first return to the scout image by touching ***Return to Scout***. To select an area of interest, simply touch anywhere inside the green box which frames the desired area and the corresponding high magnification image will appear. Repeat steps in Section 3.6 to view and save any of the high magnification images.

If you have placed one green box inside of another, you can select the larger of the two boxes by touching inside of its borders but outside the border of the smaller box. Choose the small box by touching as close to its center as possible.

The operator has the option to return to the scout image to select additional areas for high-magnification images by touching ***Return to Scout*** *Image.* The system will return to the *Scout Image Display, Select HI-MAG* screen, where the operator can select more areas of interest to be magnified. Don't forget to save any important images by pressing ***Record Image***.

When finished with the examination, touch ***Home*** to return to the *Main TSS Window.*

3.7 Recalling Stored Images

To recall and view stored images, touch ***Single Station, Recall Old Image*** from the main menu. The computer will provide a list of all scout images that have been stored. The operator may select any scout image and its associated high-magnification images to be recalled and viewed.

To view a scout image, select the number of the scout image you wish to view by using the scroll bar to the right of the *Scout Image* window. Touch ***View Scout*** when the desired slide number is highlighted in blue. The date, time and source of capture will be displayed beneath the thumbnail.

Once an image is chosen, there is the option to transmit a scout image from the scout image display screen by pressing the ***X-mit S Image***. When you return home, the system will request that you chose a receiving location. A progress bar will document the transmission process.

To view a high-magnification image you must return to the *Recall Stored Images* screen and select the number of the high-magnification you wish to view by using the scroll bar to the right of the *Hi-Mag Images* window. Touch ***View High Mag.*** When viewing a stored image, there is no way to jump around the image, or adjust the light or the focus, since the frame showing on screen has been recorded as is. The image may be transmitted by touching ***Send*** Image and following the prompts. By touching ***Back***, the operator will return to the *Recall Stored Images* window.

The only way to access additional saved regions is by returning to the main list of stored images, and selecting the corresponding number directly from the main list.

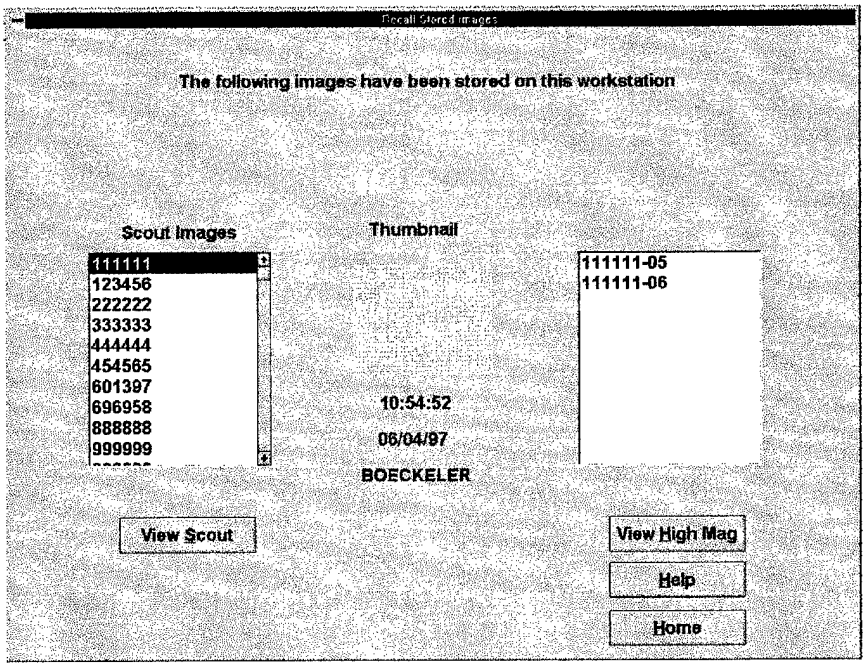


Fig. 11 - An example of the Recall Stored Images screen.

4. REMOTE MODE - SENDING

Remote Mode - Sending is used when the operator wishes to transmit an examination to a remote location for evaluation. The sending station's roles are (1) to create the initial scout image by scanning the microscope slide, and, at the request of the receiving station, (2) make and transmit high-magnification images of locations selected by the receiving station

4.1 Preparing a Scout Image for Transmission

Capturing a scout image for transmission should be done in the same manner as described in the Local Mode section. Touch ***Single Station New Image Send and View.*** Continue as directed in Sections 3.1 - 3.4, by entering the slide accession number, loading the microscope slide, and waiting as the scanner produces a scout image of the slide.

4.2 Transmitting a Scout Image

When the scout image appears on the screen, touch ***X-mit S Image*** to transmit the image to a remote station. The image will be queued for transmission. When you are finished viewing, and you have returned home, The *Address Book* will automatically be displayed. (Please see Section 9 for directions on adding and deleting entries from your Address Book.) Choose a receiving station by touching the desired remote location. The selection will be highlighted in blue. Touch ***Select.***

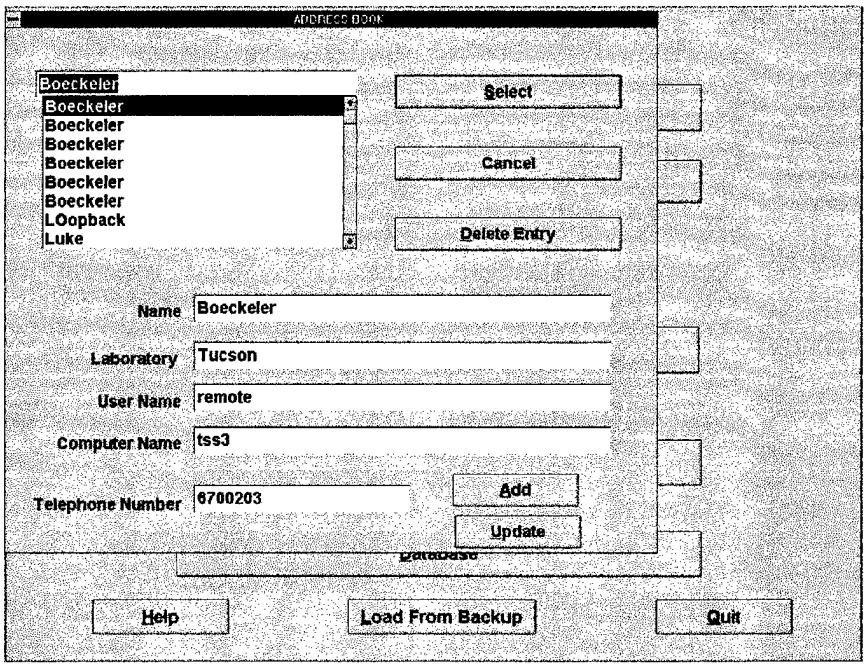


Fig. 12 - Example of the Address Book used to transmit images to different systems.

Once a location for transmission is specified, the user has the option of recording a message. A dialogue box will automatically appear asking, "*Do you want to record a message?*" If you wish to record a message, touch ***Yes***. Recording begins immediately showing a display of elapsed time. When finished recording, touch ***Stop***. In case an error was made during recording, touch ***Restart*** and record the message again. Touch ***Exit*** to end the recording session. A new dialogue box will appear requesting that the user click on ***Send*** to initiate transmission. The scout image will be transmitted to the chosen remote station. A progress bar will appear to document the connection with the remote station and the transmission of the image. Allow 5 to 6 minutes to complete transmission. [Note: Any green boxes which have been selected at the original location are not sent along with the scout image. The image is sent free of any overlay.]

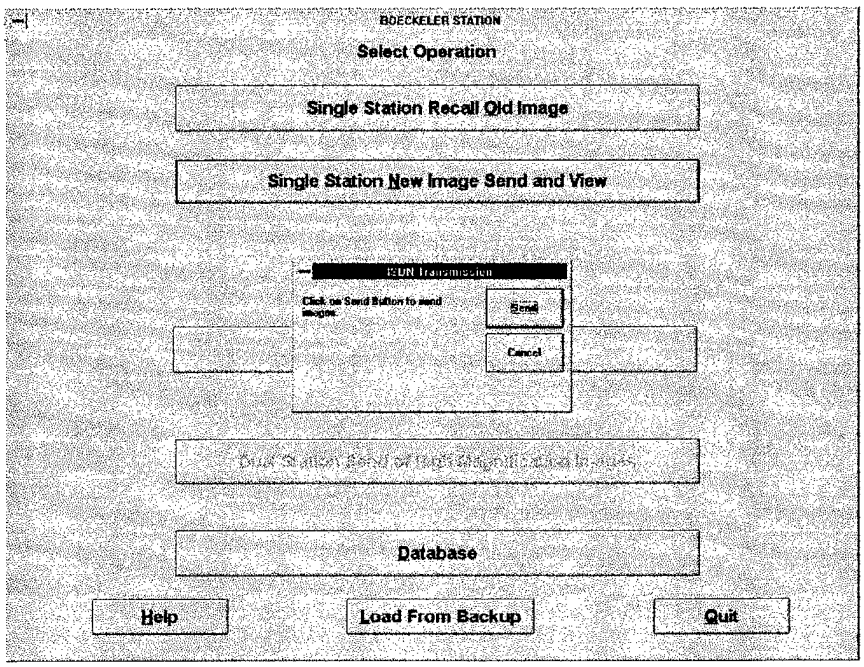


Fig. 13 - The dialogue box which documents transmission of an image to a remote station.

4.3 Receiving Requests for High Magnification Images

The remote station will receive the scout image, and areas of interest will be chosen for higher magnification. When the requests for these images are sent back to the original station, ***Dual Station Send of High Magnification Images*** will become highlighted on the *Main TSS Window*. Touch the button to begin filling the requests.

The *Request to Load Slide Window* appears, showing how many high magnification images were requested for any given slide number. If the correct slide is not already resting in the microscope carrier, load the slide into the carrier and touch ***OK***. The operator will be given the option of playing a message if one was recorded at the remote station.

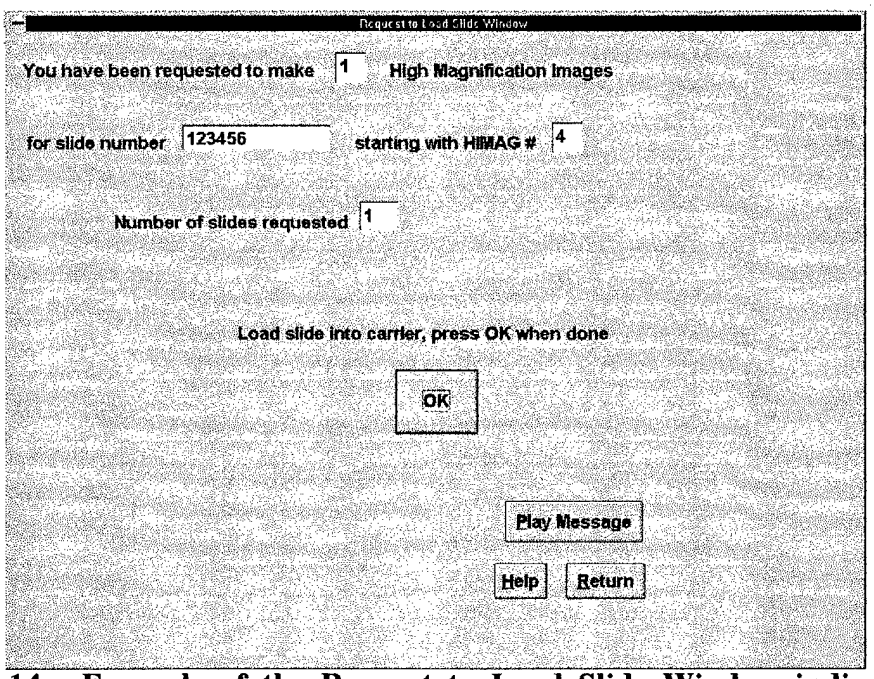


Fig. 14 - Example of the Request to Load Slide Window indicating how many high magnification images have been requested.

4.4 Sending High Magnification Images

The *High Magnification Image Window* will appear, showing the first X,Y location requested at the appropriate magnification. Focus the image using the up/down slider on the display screen. The operator has the option of changing the magnification, or "jumping" around to adjust the location of the image to be sent. However, it is a good idea to leave it at the original location and magnification since the image corresponds to the coordinates requested at the remote location.

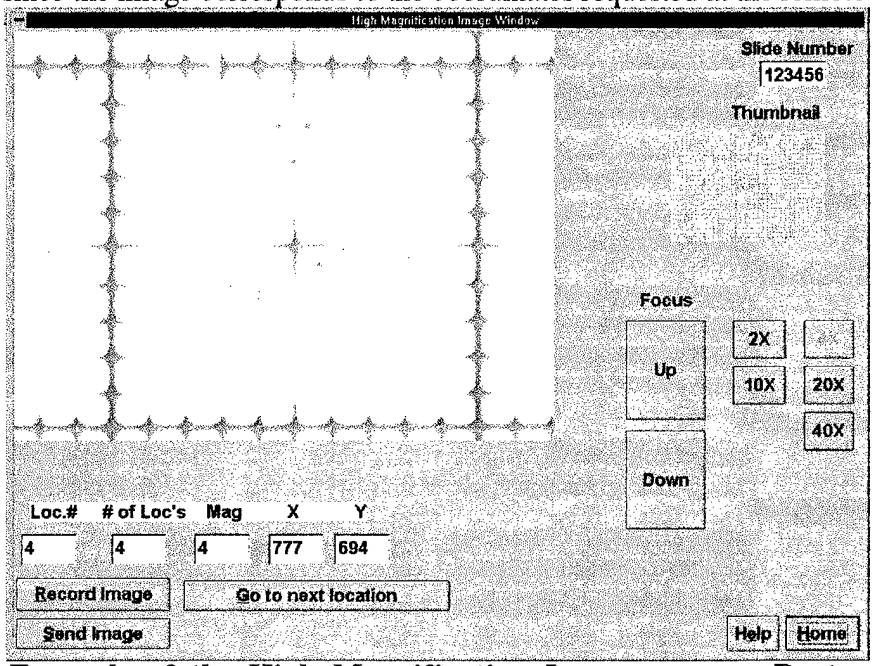


Fig. 15 - Example of the High Magnification Image screen. By touching the Send Image button, the image will be marked for transfer to another system.

Touch ***Send Image*** to mark the image for transmission. A dialogue box will appear offering the option to record a voice file. When recording is complete (See Section 4.2 for further recording instructions.), *"X-mit request added,"* will appear on the screen. Touch ***O K.***

To move to the next X,Y location requested, touch ***Go To Next Location.*** The microscope will automatically adjust to the appropriate location and magnification, but again the operator will be responsible for focusing the image.

Continue to fill all of the requests for high magnification images by following the steps in Section 4.4. When there are no more requests to fill, touch ***Go To Next Location*** to return to the *Recall Stored Images Window.* Touch ***Cancel*** to return to the *Main TSS Window.* At that time, all of the images captured will be sent to the remote station, and are saved at the operator's station. A progress bar will display the progress of the transmission.

4.5 Receiving a Diagnosis

After the remote station has received and the requested high magnification images have been viewed, any image with an important attached voice file can be sent back to the original sending station.

5. REMOTE MODE - RECEIVING

Remote Mode - Receiving is used when the workstation receives a scout or high-magnification image(s) from another workstation for evaluation. If a scout image is received, the examining pathologist selects areas of interest for high magnification and returns the request to the sending station. When the high-magnification request is returned, the pathologist may proceed with an evaluation.

5.1 Receiving a Scout Image

When a remote transmission of a scout image is completed, the ***Images Received*** button becomes highlighted on the *Main TSS* window. The transmission of an image takes approximately 5 minutes.

5.2 Viewing a Scout Image

Touch ***Dual Station Receiver***. This will bring up the *Recall Stored Images Screen.* From this screen, scroll down the list of scout images to the one or ones that have just been transmitted. The time, date, and place where the image originated will be displayed beneath the thumbnail of the image selected. Highlight the slide number to be viewed.

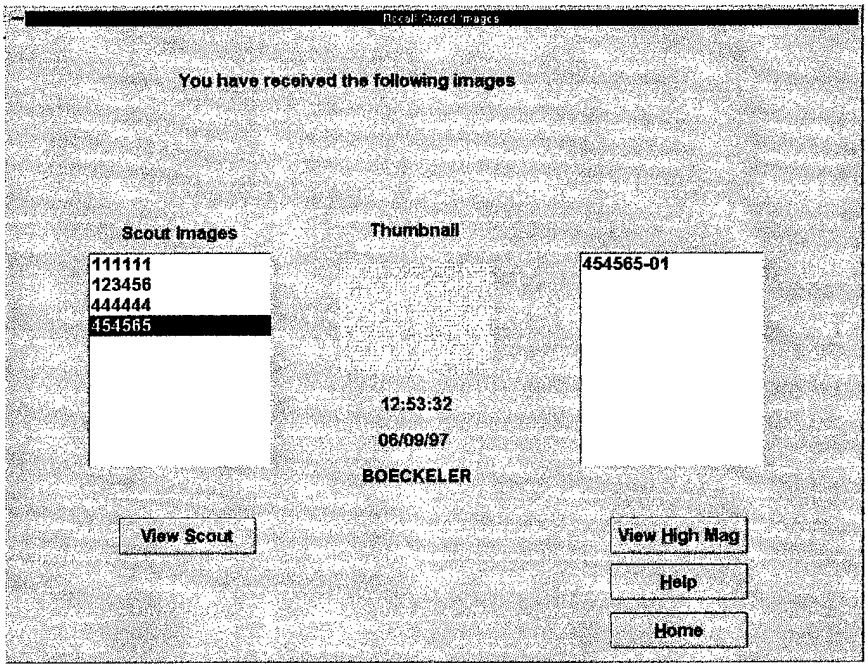


Fig. 16 - Example of the Recall Stored Images screen displaying images which have been transmitted to the system.

Touch ***View Scout Image***. This will load the scout image and display it on the *Received Scout Image, Select HI-MAG* screen. This process will take approximately 1.5 minutes. The operator may listen to a recorded message regarding the slide by touching ***Play Message***

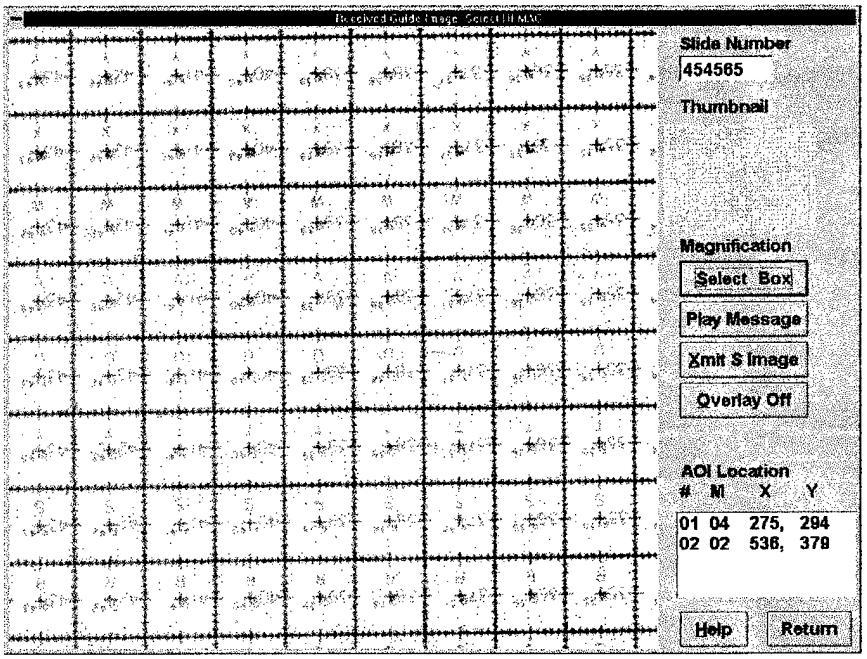


Fig. 17 - Example of the Received Scout Image, Select HI-MAG screen.

5.3 Marking Areas of Interest for Magnification

To mark areas of interest (AOI) for high-magnification examination touch ***Select Box.*** A dialogue box will appear with magnification buttons for 2X, 4X, 10X, 20X, and 40X. Choose the desired magnification. . A small, square, black marker will appear on the screen in place of the white arrow marker. Touch the location on the scout image to be magnified. A black box surrounding the area to be magnified will appear. If the box needs to be moved to a more specific location, use the arrow keys on the keyboard to move left, right, up, or down. **Once the screen is touched again, the AOI box will turn green and become fixed in that location.** The size of the box surrounding the AOI will correlate with the desired magnification: a large box represents a low magnification while a small box represents a high magnification. In addition, the coordinates and the chosen magnification of the area will appear in the AOI Location Box in the lower right corner of the screen. The operator may continue to select locations and magnifications as desired.

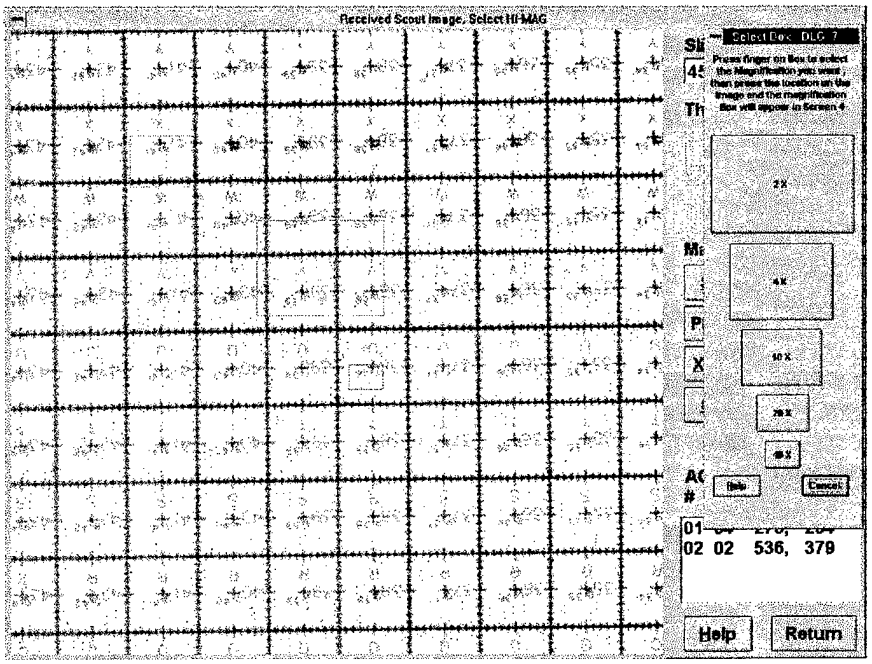


Fig. 18 - Example of the Selection Box used to mark areas of interest for higher magnification.

5.4 Sending a High-Magnification Request

When all areas to be magnified have been selected, touch ***Get HM Image.*** The *Address Book* will appear. Highlight the receiving station and touch ***Select.*** The *Do You Wish to Record A Message?* box will appear. If you touch ***Yes***, recording will begin immediately. Record a message and touch ***Stop.*** To replace the message, touch ***Restart*** to begin recording again. Touch ***Stop*** and then ***Exit*** when finished. If you do not wish to record a message, touch ***No.*** A box stating *Request for HM Images Queued* will appear. Touch ***Okay*** to signal the station to prepare to send the images. The *Recall Sent Scout Images* screen will appear again. The operator **must exit** the *Recall Sent Scout Images* screen and return to the *Main TSS Window* to begin transmission of the requests for high-magnification images to the other station.

5.5 Receiving the High Magnification Images Requested

Images Received become highlighted when your high magnification requests are returned. Touch ***Dual Station Receiver*** to bring up the *Recall Stored Images* screen. Highlight the correct scout image slide number. The corresponding high magnification images should appear in the *High Magnification Box* on the right side of the screen.

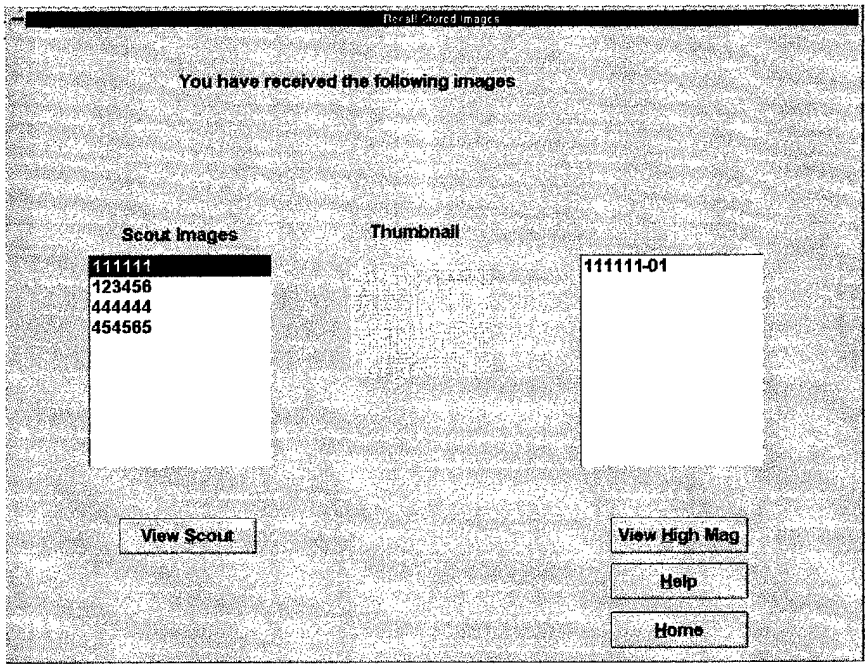


Fig. 19 - Example of the Recall Stored Images screen displaying the highlighted scout image and its corresponding high magnification images.

5.6 Viewing High Magnification Images

Select a high magnification image to examine and touch ***View High Mag***. The *Received High Magnification Image* screen will appear with the first requested high magnification image. A thumbnail of the scout image will appear in the upper right corner of the screen, with cross-hairs indicating which region is currently being examined at high magnification. The *Location #* will appear showing which high magnification image is being viewed (i.e. the first ,the second, or the third), as well as the X,Y coordinates and the magnification of that image. The *# of Loc's* will be displayed specifying how many high magnification images are present for the chosen scout image. Touch ***Play Message*** to hear any recorded message corresponding to the selected high magnification image.

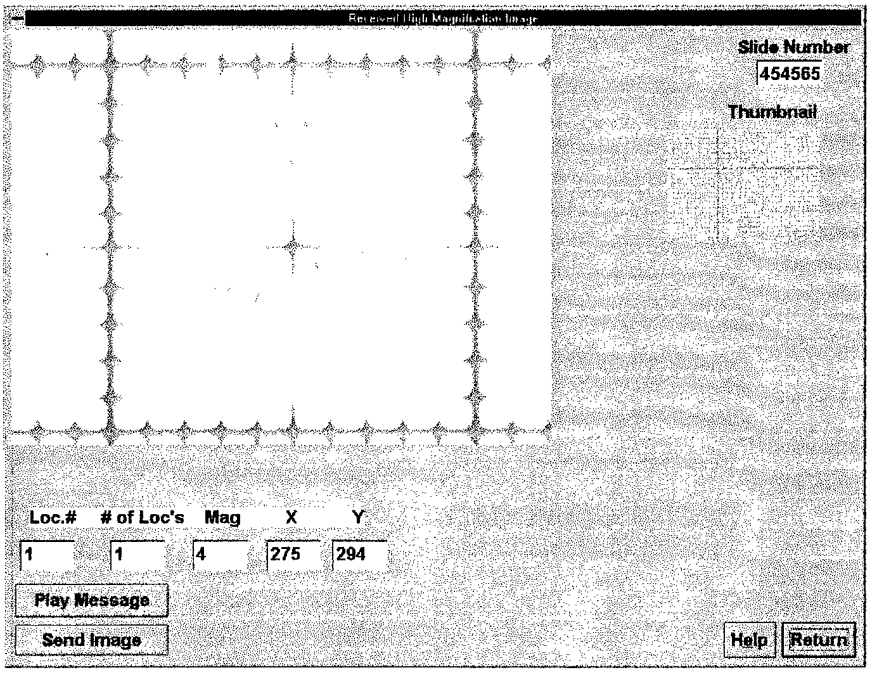


Fig. 20 - An example of the Received High Magnification Image screen.

To view the other high magnification images requested, return to the *Recall Stored Images* screen, and choose any high magnification image of interest. If no other high magnification images for the current scout image are available, the operator may go to another scout image and view its associated high magnification images also.

5.7 Recording a Diagnosis

To record any comments or diagnoses, touch ***Record Message.*** The *Record/Playback Message* window will appear on the screen and recording will being automatically. If during recording a mistake was made, touch ***Stop.*** To record another message, touch ***Restart.*** Touch ***Stop*** to end recording the message and ***Exit*** to remove the *Record/Playback Message* window.

6. NAVIGATING THE DATABASE

The database function is currently under construction. Please return to the main menu by touching ***Home.***

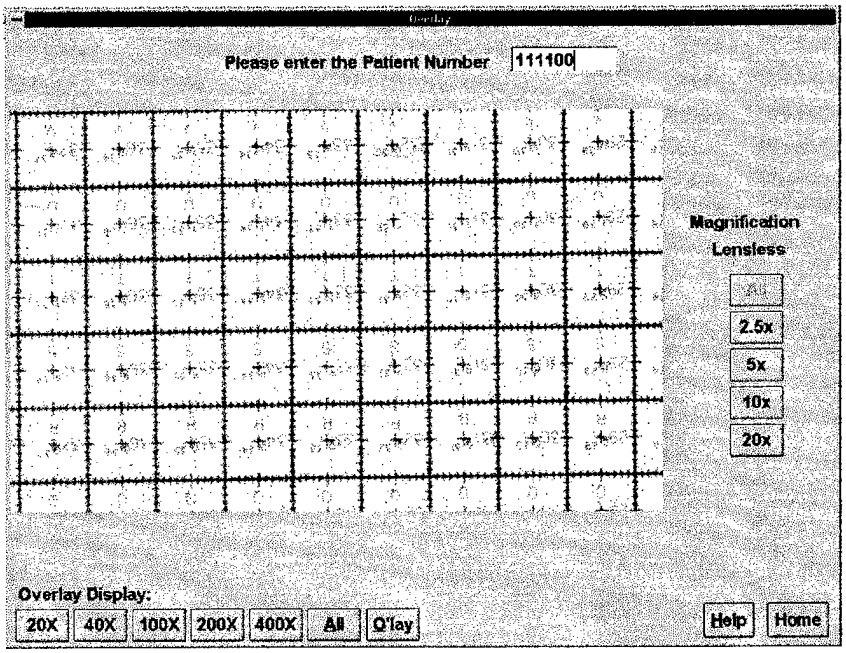


Fig. 21 - Example of the Database screen.

7. THE AUTOMATIC BACKUP FUNCTION

When a case is saved using the TSS, the information is stored on the hard drive. The amount of memory available for this function is quite limited. Therefore, an automatic backup function was added for the convenience of the user. This function requires that the user insert an empty 270MB Syquest cartridge into the Syquest drive onto which the cases will be stored. Ultimately, the cases are erased from the hard drive to free up space for new studies.

When the cases stored on the hard drive take up an amount of memory exceeding 200MB, a dialog box will appear prompting the user to insert a blank Syquest cartridge and back up the hard drive. The user may not disregard the prompt, or select only some cases to back up - **all cases will be backed up when the hard drive is full.** Insert the cartridge into the Syquest drive and touch ***O K*** to initiate the backup process. All case numbers will be displayed as they are transfered to disk. The cases will then be erased from the hard drive. Therefore, it would be helpful to record which cases were transferred to a particular disk so that they can be easily accessed in the future.

8. LOAD FROM BACKUP

Once cases are removed from the hard drive, they can not be accessed by simply pressing ***Single Station Recall Old Image*** at the main window. The case must first be loaded back onto the hard drive from a backup disk. Find and insert the Syquest cartridge with the desired case, and touch ***Load From Backup*** at the main window. A dialog box will appear, requesting the user to select which case they wish to load.

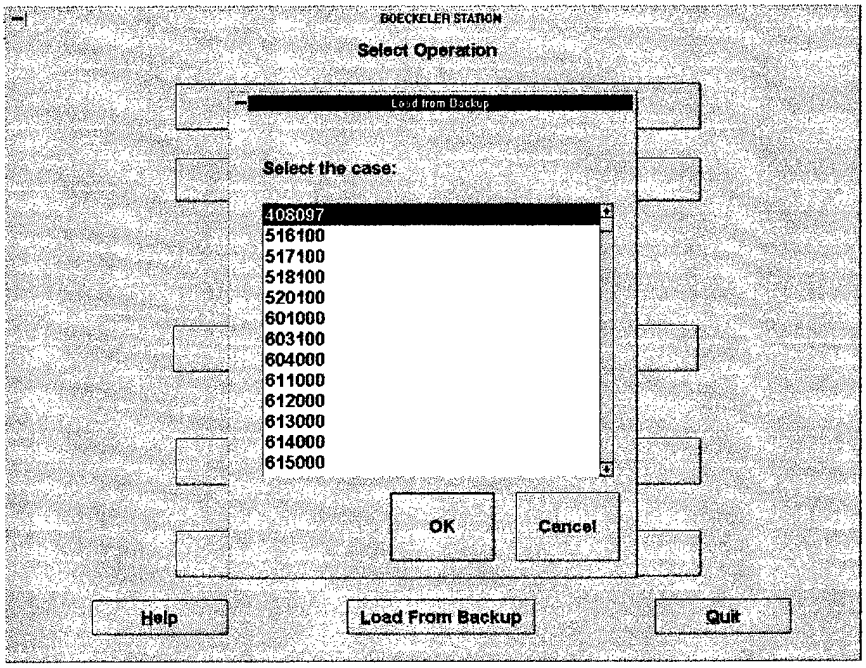


Fig. 22 - Choosing a case to load from a backup disk.

When the case number is highlighted, touch ***OK*** and the case will be copied onto the hard drive for viewing. When the user needs to access this case, simply touch ***Single Station Recall Old Image*** at the main window and follow the steps listed in section 3.7.

9. SHUTTING DOWN THE WORKSTATION

To shut down the workstation, first return to the *Main TSS Window* by touching ***Home*** from any window. Press ***Quit*** to end the session. From the dialogue box which appears, select ***Shutdown***. When prompted to shutdown, turn the green switch on the Powercell to the "Off" position. The entire workstation will be powered down. Replace the lens cap and microscope's vinyl dust cover, and wipe the touch screen clean of any fingerprints.

10. CARE AND MAINTENANCE

10.1 When not in Use

Always replace the lens cap on the condenser of the microscope which is located at the base of the microscope. Replace the microscope dust cover after each use.

10.2 Cleaning the Screen

Clean the touchscreen regularly with a household glass cleaner and paper towels to remove fingerprints and to maintain a clean, clear view of all images. Slightly dampen a towel and clean the touchscreen.

10.3 Cleaning the Microscope

To keep the microscope clean, wipe the stage with a soft cloth (silicon cloth is recommended). Avoid the use of any organic solvent on the painted and plastic surfaces of the

microscope. Dust can be brushed off the lenses, or wiped with lens tissue or a soft cotton cloth to remove fingerprints. It is safe to use pure alcohol if needed.

10.4 Do not Disassemble the Instruments

Remember, any damage caused by unauthorized use will void the warranty.

11. ADDING, EDITING, AND DELETING ENTRIES FROM ADDRESS BOOK

To add a name to your *Address Book*, simply touch on the **Name** box to move the cursor to that location. Type in the name of the person or system you wish to add. Press "Tab" on the keyboard to move to the next field, and continue to enter the information required: the laboratory at which they are located, the person's user name, the computer name, and the ISDN telephone number for that system. When this is finished, touch ***Add***.

If a person or system needs updated information, first highlight the name in the *Address Book* to bring up the detailed information below. Then simply change the information that needs updating. Touch ***Add***.

To delete a name from the *Address Book*, highlight the name and touch ***Delete Entry***. This will permanently delete the name from the address book.

12. TROUBLE-SHOOTING

Only the solutions to the problems covered in this section should be attempted by the user. If the answer to your problem is not listed below, please call Kensal Corporation.

12.1 Turning On the System / Logging On

The green button located on the Powercell is the only power switch to turn on before using the system. If you are having problems turning the system on, check that all electrical plugs are in their outlets and all connections between the computer and the microscope are secure.

Once the system has been turned on, the operator must log on to the program by entering the username and password assigned to the system by a Kensal technician. Press "Ctrl + Alt + Del" and the *Welcome* dialogue box should appear, prompting you to enter the information. When finished, press "Enter" on the keyboard, and wait about thirty seconds for the *Main TSS Window* to appear. If any problems arise, try restarting the system. If problems persist, contact Kensal Corporation.

12.2 Problems with the Touchscreen

If you are having trouble with the touchscreen, remember to press very firmly when you make a selection, and immediately release. The arrow that appears under your findertip will indicate exactly where you have touched on the screen. The system will make a beeping sound each time you touch the screen, however this does not necessarily indicate that you triggered the intended "button". If nothing happens, regardless of whether the system beeped, try touching the screen again, correcting your positioning to get the arrow onto the desired location.

If you are accustomed to using a mouse, you may request the technician to connect one to your system. When using a mouse, you simply position the arrow over the "button" you wish to press, and click the left button once, unless otherwise indicated. This may be especially helpful for using some of the scroll bars and smaller buttons. The touchscreen will still be activated should you wish to use both a mouse and the touchscreen.

12.3 Opening the TSS Program from Windows NT

If at any time the TSS program is exited, the system will display the Windows NT Program Manager on the desktop. It is not difficult to relaunch the program from this point. From the desktop, touch twice on the Program Manager icon in the bottom left corner of the screen. When the window entitled Program Manager - TSS/Administrator appears, click twice on the *Startup* icon at the bottom of the screen. When the *Startup* box appears, choose TSS from the box by clicking twice on the camera icon. This should return you to the *Main TSS Window.*

Sometimes the TSS application is not exited, but gets covered up by another open window. To return to the *Main TSS Window*, press and hold down the "Alt" button. A small window will appear in the center of the screen displaying the name of the program which is currently open. While holding the "Alt" button down, press and release the "Tab" button to toggle through all the open applications. Continue to press "Tab" until the name TSS appears. Release both the "Tab" and the "Alt" buttons to jump back to the TSS program.

If you are unable to return to the TSS program, restarting the computer and logging on from the beginning is a simple solution.

12.4 Problems Loading the Slide

Make sure the microscope slide is face up and the label is toward the back of the microscope. Gently glide the slide into position and secure it with the specimen holder. Sometimes using an object such as a pencil eraser to push the slide into place can be helpful when working in such a small area. See Figure 4 for proper slide orientation.

12.5 Problems with the Stage

If the stage is making any clicking or grinding noises during scanning, or if the slide is not entering the scan box when directed to create a scout image, immediately contact a technician. Do not attempt to rescan unless directed to do so by the technician.

12.6 Problems Producing a Scout Image

If the scout image on the screen appears white, check that the slide is facing up, and that it is placed in the specimen holder with the label towards the *back* of the microscope. The lensless scanner only views the forward section of the slide, so if a slide is put in place backwards the resulting scout image is of the label instead of the tissue.

If the image appears washed out, blurred, or streaked, check that the slide is laying flat on the stage, well secured by the specimen holder, and rescan the specimen. It is often helpful to run a few trial scans to allow the system to warm up. Fingerprints and dust on the coverslip will blur the image, so it is important to clean the slide well before scanning. The slide can be wiped clean with a soft cloth or tissue, and dust can be removed using a can of condensed air. If there are still problems with the image quality, contact a technician.

12.7 Problems Viewing a High Magnification Image

If you are trying to look at an area of interest, but no high magnification image appears, check that the lens cap has been removed from the microscope. Be sure that the appropriate slide is secured on the stage. The objective lens on the microscope should be locked into position, not resting between notches. If there is still no image, contact a technician.

When an image appears it is often very blurry. If you are having trouble focusing the image with the focus button on screen, keep in mind that the process occurs slowly. The focus

buttons correspond to the fine focus knob on the microscope, so you must hold the button in the up or down position while the focus slowly adjusts. If the image still does not appear focused, use the focus knob on the microscope itself. This is the large black knob located on the right side of the microscope, near the back. There are two portions to it: the part closest to the microscope body adjusts the coarse focus while the outer part adjusts the fine focus.

If after adjusting the focus the high magnification image still appears cloudy or dark (especially at a 40X magnification), you can manually adjust the filters to allow more or less light to pass through. The filters are located on the right side of the microscope base, towards the back. Adjusting any of the six filters will change the light intensity of the image, making it lighter or darker depending on if you push in or let out the buttons. Find a light level that allows you to see the most detail before you capture the image since light adjustments can not be made on a fixed image.

12.8 Problems Sending or Receiving an Image

If there is a problem transmitting an image, an error message will occur. Typically it takes up to a minute for this message to appear because the system will make several attempts to complete the transfer before recognizing the error.

In order to send or receive an image, **both** systems must be turned on. If a transmission error message appears, check with the receiving end to be sure their system is turned on. If the problem continues, next check in the address book that the ISDN telephone number is correct for the remote system.

Your phone company is responsible for setting up and providing the service for your ISDN lines. If a transmission error occurs, please check with your local phone company regarding the status of your ISDN lines. Contact a manufacturer technician if you are still unable to send or receive images at your workstation.

12.9 Problems Choosing an Area Of Interest (AOI)

If you are having problems getting a box around the exact location to be magnified on a scout image, remember that as long as your finger/pointer remains on the screen, the black marker will follow your touch. If, when you take your finger/pointer off the screen, the marker jumps, simply adjust its position with the arrow keys on the keyboard. The box will remain black indicating that it can still be moved. Do not try to readjust it with you finger/pointer. As soon as you touch the screen again with your finger/pointer, the box will turn green and become fixed in that position.

12.10 Problems Recording/Playing a Message

If you are having problems recording a message, make sure that the microphone is turned on. There is a switch on top of the microphone; check to see that it is in the "On" position. Try recording the message. If you are still unable to record a message, contact a manufacturer technician.

If you are having problems hearing a recorded message and you know that there is in a fact a message to be heard, check that the speakers are turned on. There is a volume knob on one of the speakers that can be turned up to increase the volume.

12.11 Using the Help Index

The operator may press ***Help*** from any screen to access the on-line Help Index. By touching any of the green, underlined commands in the menu, the corresponding help file will appear on screen. To return to the help menu, touch ***Back***, found on the gray menu bar at the top of the screen. Browse the help application by pressing on the ***Search*** option. To exit *Help*, touch ***File*** on the white menu bar, and when the menu drops down, touch ***Exit*** to return to the *Main TSS Window.*

13. GLOSSARY OF TERMS

AOI	"Area of Interest"; regions which a pathologist feels might be helpful in making a diagnosis; usually marked regions on the scout image which are to made into high magnification images
CCD Camera	"Charged Couple Device" camera; a picture-taking device which records lensed microscopic images
Computer tower	The multimedia computer including the hard drive of the TSS
Cross-hairs	Two lines criss-crossed showing the location being viewed on a scout image
Field Finder	The sample slide that comes with the TSS
Scout Image	The lensless image of a full-coverslip glass slide
HM	"High Magnification" image
ISDN Lines	"Integrated Service Digital Network" lines; high-speed telephone lines
JPEG	"Joint Photographers Expert Group"; a standard for image compression
Jumping	A process to scroll and view images by; any touched region of an image will "jump" to the center of the screen
Lensed Scanning	Microscopic images produced with a camera, such as the CCD camera
Lensless Microscopy	The application of a microscope which requires no lenses; permits rapid, full-coverslip imaging at a very high resolution of microscopic slides.
Local Mode	Referred to when the TSS is used as a stand-alone system
Real-time	The actual time in which a physical process takes place; live transmission
Remote Mode	Referred to when the TSS is used for sending and receiving images in conjunction with a second workstation

Resolution	The process or capability of making distinguishable the individual parts of closely adjacent optical images.
Specimen Holder	The latch that holds the glass slide in place on the microscope stage
Static Image	Fixed in place; stationary
TSS	"Telemedicine Support System"; a telecommunications system for pathology that integrates lensless imaging with lensed imaging.
Thumbnail	A small representation of the entire scout image

APPENDIX B

TPW DESIGN DOCUMENT

Tele-Pathology Workstation Interface and Object Design

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Date:
22 February 1997

1 INTRODUCTION

This design document has been prepared for the perusal and use of the software implementation team. This design contains all information needed to fully develop the Tele-Pathology Workstation Software. It is understood that some items may change and some items could simply not be identified at the time of writing this document. In these cases the resolution will happen during development to the satisfaction of Kensal.

The Tele-Pathology Workstation is designed to be utilized by multiple pathologists working at various locations around the world. At the time of this writing the usage will be limited to pathologists communicating via a network of ISDN Connections. The system is designed to be a communal workstation (multiple users at one site) with a built in camera unit, 1280x1024 monitor, running on an Apple PowerMac 9500. The software will be developed using Symantec C++ 8.0 (or later) with the Think Class Library (TCL).

The system is built on a main window which is used for the majority of the interface. Dialog boxes and floating windows supplement the interface where needed. See Section 2 for a detailed discussion of each interface object. The system will operate in what has been termed "modes". Each mode is defined in section 3 and includes a flow chart which outlines the operation of each course of action (see below for a brief introduction to the modes). Section 4 describes the C++ Class Objects which will be developed during the implementation phase. A complete identification of the files needed to implement the system is described in section 5.

The primary product of the Tele-Pathology Workstation is a set of images of which there are two types. The first type is the guide image of which there will never be more than one per slide analysis session and it will always be a scan of the entire slide at 4000x8000 pixels. The second type will be the high magnification images which will have many occurrences at various locations and magnifications throughout the slide. See section 5 for a discussion of these and other file types.

One of the more confusing aspects of the Tele-Pathology Workstation is the concept of modes. These modes are necessary so that when the user is performing a given function that the system operates in a manner unique and consistent to that function. A mode describes an environment in which the user operates to perform the aforementioned function. It is important to note that rarely will a particular user operate in all of the modes. Typically the user will operate strictly as either the remote expert or the local technologist. The modes are identified as:

Dual Station

Generate Guide and Transmit
The local user will generate a guide image and transmit to the remote expert a request for analysis of the slide.

Request High Magnification Images
The Remote expert will review the guide and transmit back to the local user a request for high magnification images at specific locations and magnifications.

Generate High Magnification Images
The local user in turn fulfills the high magnification request and returns to the expert the specified images.

Diagnose From Images
After having received all images necessary the remote expert will dictate various voice message diagnoses and transmit to the local user the request for transcription.

Transcribe Diagnosis
The local user performs the transcription task for the slide analysis session which completes the Dual station analysis.

Chat

The chat is a mode modifier in that a chat can be requested with virtually any user at any time from any mode. During chat the users involved will be essentially sharing screens and communicating over the voice channel as if on the telephone.

Single Station

Examination

If the user generates a guide and then goes on to analyze the slide at high magnification they will be automatically placed in examination mode.

Review Overlays and Diagnose

To conclude the Examination the user leaves voice messages at various locations and submits the session for transcription.

Database

There will be available to the user a selection of databases through which browsing is possible. These databases could be the users own cases, Kensal supplied cases on CD-ROM, or various Internet sites.

2 INTERFACE LAYOUTS

test The following figures are the proposed windows and dialogs making up the Tele-Pathology Workstation. Accompanying each interface is a set of layout objects which are identified in the subsequent text. Each object is then discussed in enough detail to describe its functionality and use. This is not intended to give the reader a comprehensive understanding of the operation of the system. For operations see section 3.

2.1 Main Window

The Main Window of the Tele-Pathology system performs all of the vital functions for the software interface. All other windows and dialogs are supplementary. When the user launches the system the main window will be displayed. The Tele-Pathology is seen as an executive type system. Executive systems have the primary requirement of ease of use. In the Tele-Pathology system this will be accomplished in the following ways.

1. No Pull-down Menu
   All of the options and commands will appear on the screen itself and give the user as much information as possible. The objects will also respond to the current mode and environment by dimming or updating their names as described below.
2. A Single Main Window
   In order to simplify the system the main window will offer at least a starting point for every function which the user needs to perform.
3. Main Window consumes entire screen
   The main window will also sense the screen size on launch and resize to fill the entire screen. This reduces clutter on screen and focuses attention on the Tele-pathology system. All window objects will maintain their relative positions and actual sizes for any screen size except for the image port which will relatively maintain both position and size.

Note that the figure below shows all controls on the main window. This is not meant to represent the window as it might actually be seen during any actual mode, but rather to illustrate the functional options in the window.

Also note that some of the buttons change names in accordance with the mode of operation. The buttons which can have different names and functions are:

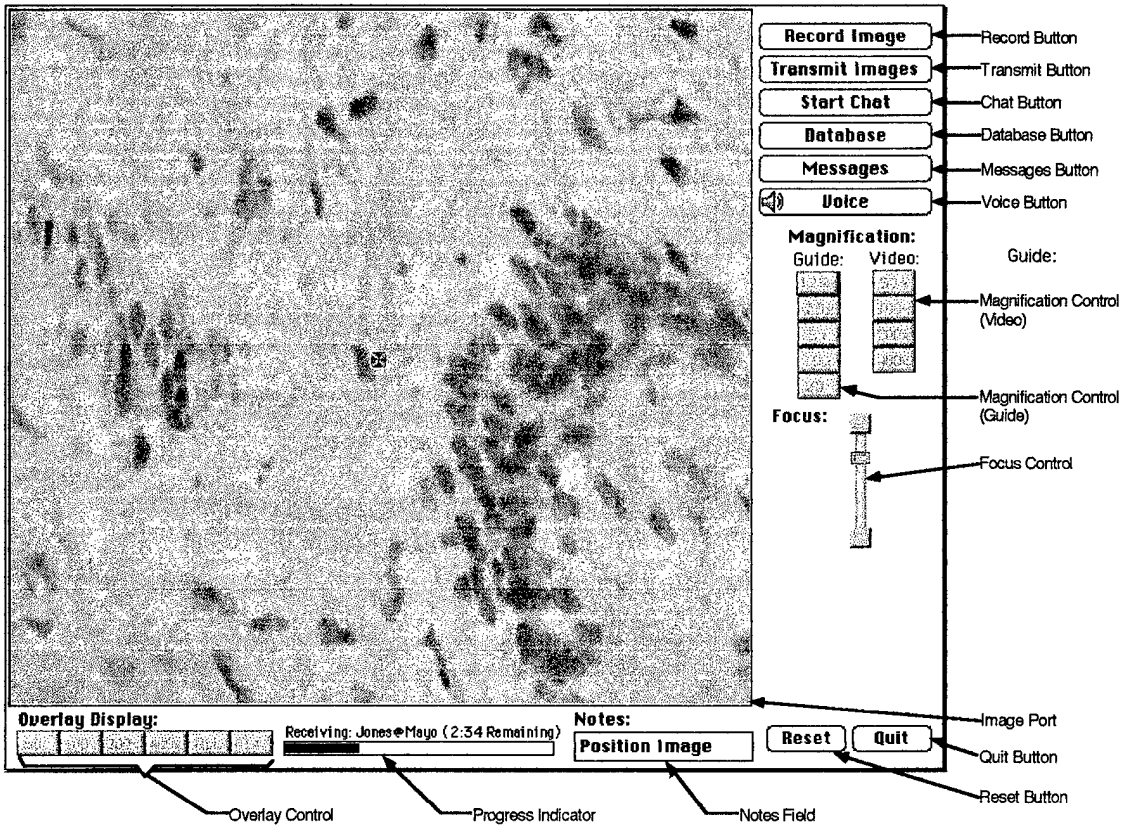
Button Name	Section	Can Read...
Chat	2.1.1	Start Chat, Resume Chat, End Chat
Record	2.1.12	Record Guide, Record Location, Record Image, Next Image
Transmit	2.1.14	Transmit Guide, Transmit Locations, Transmit Images, Transmit Diagnosis

Throughout the following text the controls will be describe in terms of various states of functionality. It is important to note that this refers to the slider and controls as well as the buttons. These states consist of:

Disabled	This will be displayed as a dimmed control. The dimming of the control indicates to the user that the control is currently not functional but that it will be once a set of criteria are met.
Enabled	The enabled control is fully functional.
Available	The available control is fully functional.
Unavailable	The unavailable control is simply not on the screen. This is most commonly achieved by hiding the control. This state is used in modes which will not ever use the control in question.

Deselected Several of the controls utilize a selection mechanism. At various times it is necessary to set all of the selections off. This is achieved by deselecting the control. The control remains fully functional.

Read Only Some of the controls are used not only to get input from the user but also to give the user information. Sometimes these controls are only for displaying the information. In such states the controls are read only.



Main Tele-Pathology Window showing all controls

The following lists each of the screen objects and their functions.

2.1.1 Chat Button

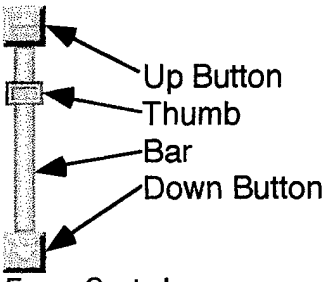
The chat button will allow the user to enter a chat. After pressing the chat button the transmit dialog will be displayed and the available chat users will be given as choices in the list. An available chat user is one who is a "direct" connection. Once the connection has been established the users will share the main image display, magnification controls, focus control, overlay Control, and Mouse. The users will also have a direct sound connection over the standard sound in and out ports. When requested to enter a chat the user will be prompted with a dialog and requested to accept or deny the chat. After connection the chat button will read "End Chat".

2.1.2 Database Button

The database button is designed to allow the user to select previously saved cases by entering search criteria for: slide number, analysis start date, analysis completion date, organization MD, medical institution, organ, disease, and/or SNOMED code.

2.1.3 Focus Control

The Focus control is made up of 4 components:



Focus Control

Each of the components work in conjunction with the others and all are live controls (meaning that they send the focus command to the camera, the camera responds and the image is updated even while the mouse button is still down). The up and down buttons will move the focus up and down (while updating the thumb position) by a scaled increment achievable by the camera. The bar will move the thumb to the position on which it is clicked and focus to that relative increment. The thumb will adjust the focus to it's incremental position while it is being drug along the bar. The number of focus pulses which the control sends to the camera is inversely proportional to the magnification of the camera. At 400x the focus control will send 1 pulse per increment. At 50x the control sends many pulses ("many" to be defined by the focus stepper motor driver).

The focus control can only be used when the slide is actually on the table. Therefore the focus control will be dimmed whenever the system is being used by the remote user or when the local user is simply viewing stored images or performing other non-image control functions.

2.1.4 Image Port

The image port will always contain the currently selected image at one of the acceptable magnifications. For a guide image creation the image port will contain the guide image at All (1.25x), 2.5x, 5x, 10x or 20x Magnification. During High Magnification viewing the image will be displayed at the selected magnification (50x, 100x, 200x, or 400x). The user will be able to jump the image using the point and click method. This method functions by clicking in the image at a point to which the user wants the center of the image to move. The center of the image will be indicated by a cross-hair type icon which remains stationary as seen above (⊠).

2.1.5 Magnification Control (Guide)

During any session the guide image is available. The guide magnification control always operates on the guide image and performs software magnifications only. The control button consist of "All" (1.25x), "2.5x", "5x", "10x", and "20x." The following chart illustrates the image sizes at the various magnifications.

Guide Magnification	Image Size
All (1.25x)	1000x500
2.5x	2000x1000
5x	4000x2000
10x	8000x4000
20x	16000x8000

2.1.6 Magnification Control (Video)

The video magnification control will be activated during high magnification request sessions. A single station session where the local user is also the expert will behave in functionally the same manner. At all other times it will be disabled but will display the current magnification. During high magnification request the magnification control will not actually magnify the control as the actual image will not be available since the magnification is being set by the remote user. Instead the guide image view area will display a dotted rectangle showing the size of the image for the selected magnification. The magnification rectangle will always be centered on the view so that after the magnification value is chosen the user can fine tune the position before pressing record button. During high magnification creation the video magnification control will drive the camera to set the requested magnification and display that image to the main image display.

2.1.7 Messages Button

All incoming telecommunications will be summarized in the message list in the messages dialog. To access the messages dialog the user will press the messages button. The messages button will only be available if messages exist which have not been responded to. Messages will remain in the list until the request has been responded to and the user quits the application. Once the message has been responded to it will disappear from the list. A permanent ASCII format messages file will be stored which logs all incoming and outgoing messages for accounting purposes.

2.1.8 Notes Field

The notes field will be updated on a active basis to instruct the user where they are, what is coming next, etc. The particular items to be included in this item are as yet unresolved and will be determined during development.

2.1.9 Overlay Control

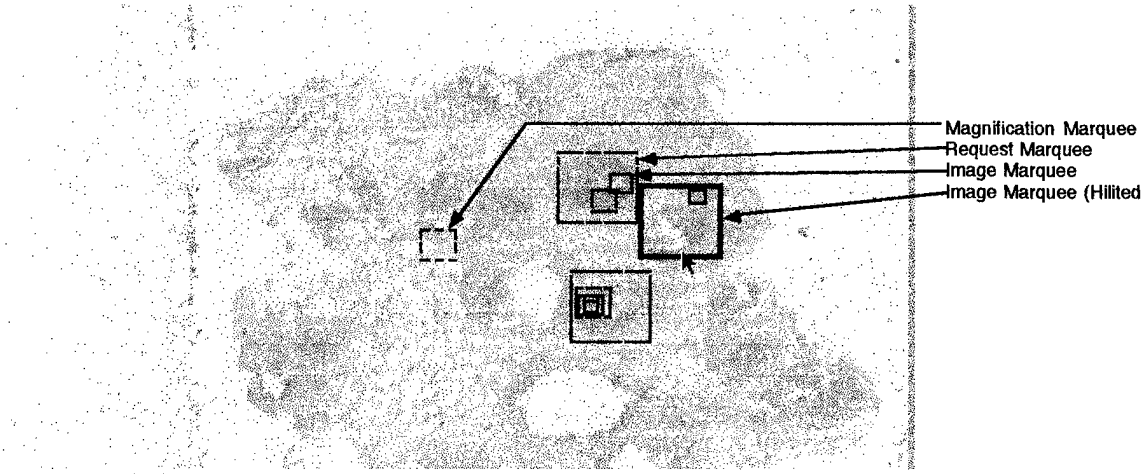
To show or hide the Overlay for a specific magnification the user will click on one or more of the Overlay control buttons. If all of the buttons get selected the "All" button will automatically depress. Conversely, If the user presses the "All" button all of the overlay magnification buttons will automatically depress. The "O'lay" button will toggle between no overlay and overlay mode. In examination mode the overlay will be seen as a series of colored rectangles (one color for each magnification) for each location which has visited by the user.

The locations at which the user has recorded an image will by displayed as black rectangles in all modes. These black rectangles shall be known as image marquees. As the user moves the cursor over these image marquees the black line will "hilite." This will allow the user to easily see which image will be selected when the user clicks. The image marquees will be arranged on the screen in such a way so as to make all images selectable.

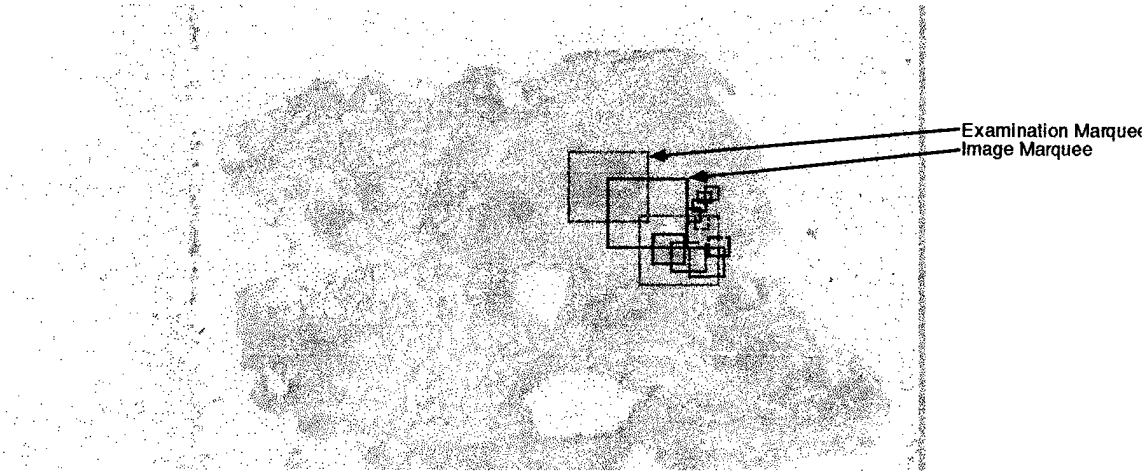
During image creation mode the locations will be indicated with black cross hairs. However only the cross hair for the current location will be displayed at any given time. These cross hairs will be known as request crosses. See section 2.8 for an example of the request cross

During examination mode when the user simply visits a site the marquees will be solid color rectangles without numbers. These color marquees shall be known as examination marquees.

During image request mode the locations will be indicated as dash line boxes. These dashed lines will be known as request marquees. Before the requested location has been recorded the image port will display a dashed line rectangle indicating the relative size of the image at the current high magnification factor. This dashed line box will use the "marching ant" mechanism for indicating the current selection and shall be known as the magnification marquee.



An image during image request mode



An image during examination mode

The overlays which are displayed on screen will be of various sizes depending upon the guide magnification. The following table illustrate the marquee size according to the image magnification and guide magnification. The table also shows the examination marquee colors.

Optical		Guide Magnification				
Magnification	Color	1.25x	2.5x	5x	10x	20x
400x	Red	5x4	9x8	18x15	32x28	64x56
200x	Yellow	10x8	18x16	35x30	65x56	130x110
100x	Magenta	20x16	36x32	70x60	130x110	324x228
50x	Cyan	40x32	72x64	175x50	324x228	648x456

2.1.10 Progress Indicator

The progress indicator will display the current status of any background operations. The text associated with the indicator will display the action (sending or receiving), remote site, and remaining time. When no activities are taking place in the background the progress indicator will not be visible.

2.1.11 Quit Button

To quit the application and return to the finder click the quit button. Any unsaved or uncommitted work will be requested to be saved or committed before exiting.

2.1.12 Record Button

During a guide image creation session the user will have loaded the slide. The record button (titled "Record Guide") will store the image to file in guide image format.

During a high magnification request session the user will position the view to the approximate location of interest and chose a magnification from the video magnification control. The record button (titled "Record Location") will store the location and magnification to a file to be transmitted to the local site. If the user is viewing previously recorded high magnification images they can step through the images by pressing the record button (titled "Next Image").

During high magnification creation the user will have chosen the image position within a selected location, focused the camera, and fine tuned the scroll to the area of interest. After having composed the image the user will save the image by pressing the record button (titled "Record Image"). The actual location will be saved with the image in addition to saving the requested location which may be different. After saving the image the record button will be dimmed until the user chooses the next location. The voice button will still be active allowing the user to store a voice message if desired. See section 3.3.

2.1.13 Reset Button

To reset the current mode and return to non-mode the user may choose the reset button. Any unsaved or uncommitted work will be requested to be saved or committed before resetting.

2.1.14 Transmit Button

The transmit button will be used initially for sending the guide image to the remote expert in guide image creation mode (button title is "Transmit Guide"). The remote user will also use the transmit button to send the location request file back to the local user during high magnification image request mode (button title is "Transmit Locations"). After all images have been recorded and voice messages stored in high magnification image creation mode, the local user will transmit the images back to the remote user by pressing the transmit button (button title is "Transmit Images"). After a analysis is complete and the remote user has dictated a diagnosis, in diagnose from images mode, the transmit button is used to send the diagnosis voice file back to the local user for transcription (button title is "Transmit Diagnosis").

When the user is in any mode other than guide image creation the transmit button will transmit to the user who requested the images, otherwise the button will invoke the transmit dialog and request the address for transmission. The transmit button will pass the image/voice file names and remote user addresses off to the communication object which will operate in it's own communication task environment.

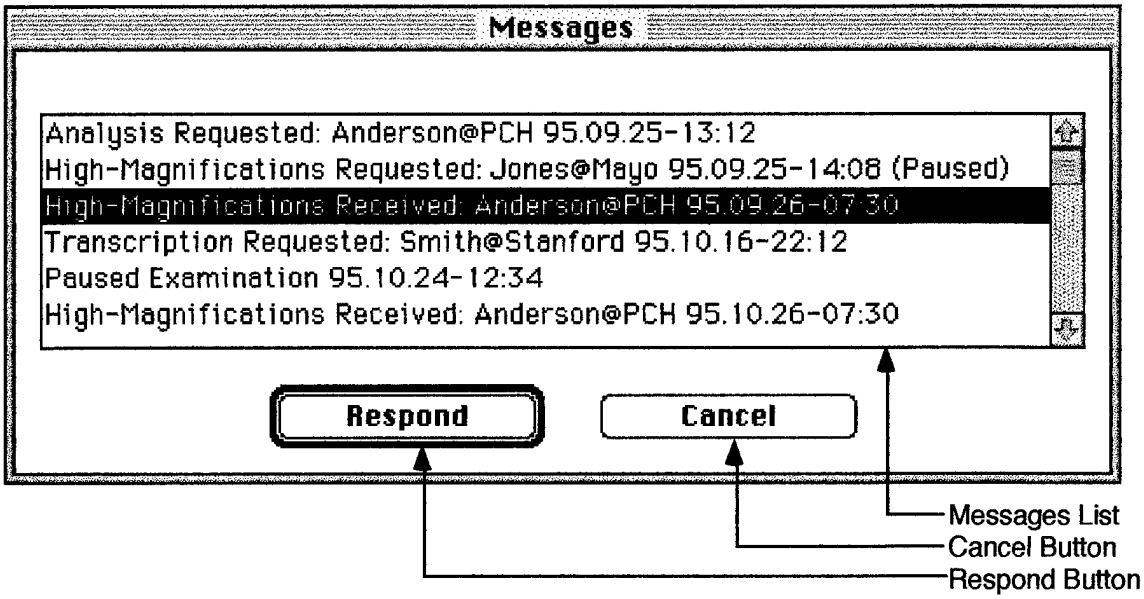
During a transmit the progress indicator will contain an indication of the transmission status and progress. This will occur at both the local and remote sites.

2.1.15 Voice Button

Messages can either be played or recorded from the voice button. The voice button will always invoke the voice dialog. If the users current location has a voice file associated with it the button will display an icon indicating that voice is available for play. The guide image itself is a valid location for voice to be associated. If the user is in a mode which does not allow the recording of voice (I.E. database or transcription) and the location does not have voice associated and neither does the guide, then the voice button will be disabled. For a complete discussion of the voice dialog see section 2.5.

2.2 Messages Dialog

In order to choose an action item and enter one of the tele-pathology response modes the user must select an item from the messages list in the messages dialog.



The Messages Dialog

2.2.1 Cancel Button

The user can abort the selection of a request by pressing the cancel button.

2.2.2 Messages List

All received requests as well as work items on pause will appear in the messages list. By default the first item will be selected. The user can select an item and press the respond button or simply double click the item.

2.2.3 Respond Button

After selecting an item in the messages list the respond button is enabled and the user can enter the mode required by the list item by clicking on the respond button.

2.3 Database Search Dialog

The search dialog is accessed when the user presses the database button from the main window or when the search button is pressed in the saved images dialog.

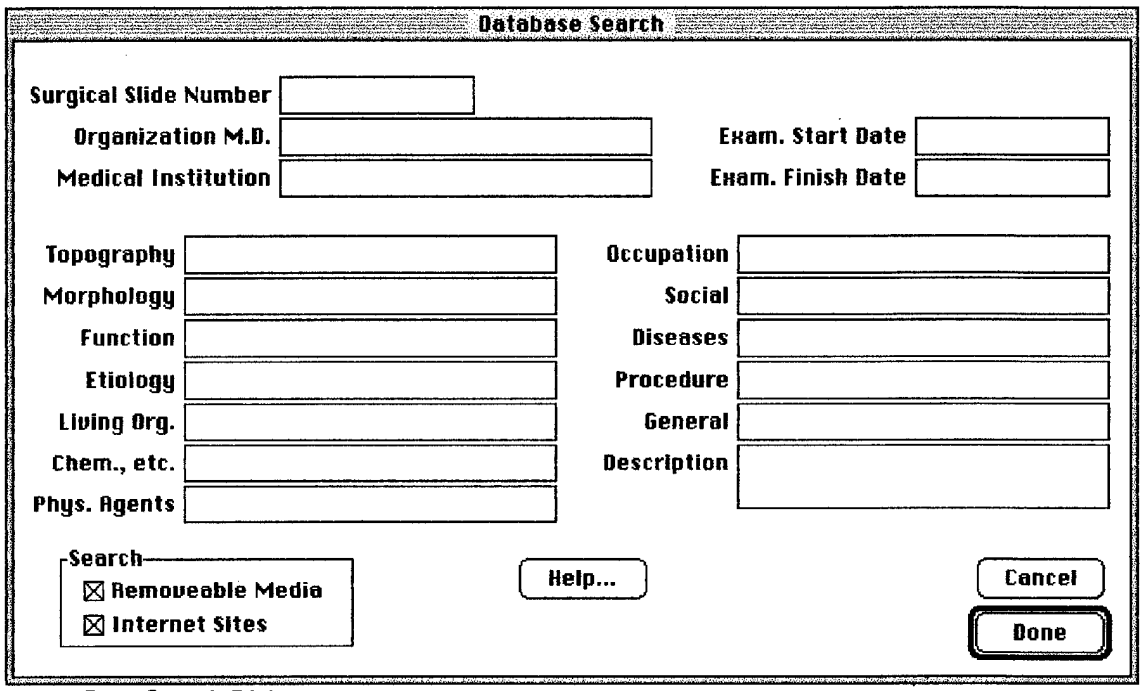


Image Data Search Dialog

2.3.1 Cancel Button

To exit without executing the search press the cancel button.

2.3.2 Databases Button

The user will be able to choose the databases which will be interrogated to find the requested images via the databases button.

2.3.3 Done Button

To execute the search press the done button.

2.3.4 Entry Fields

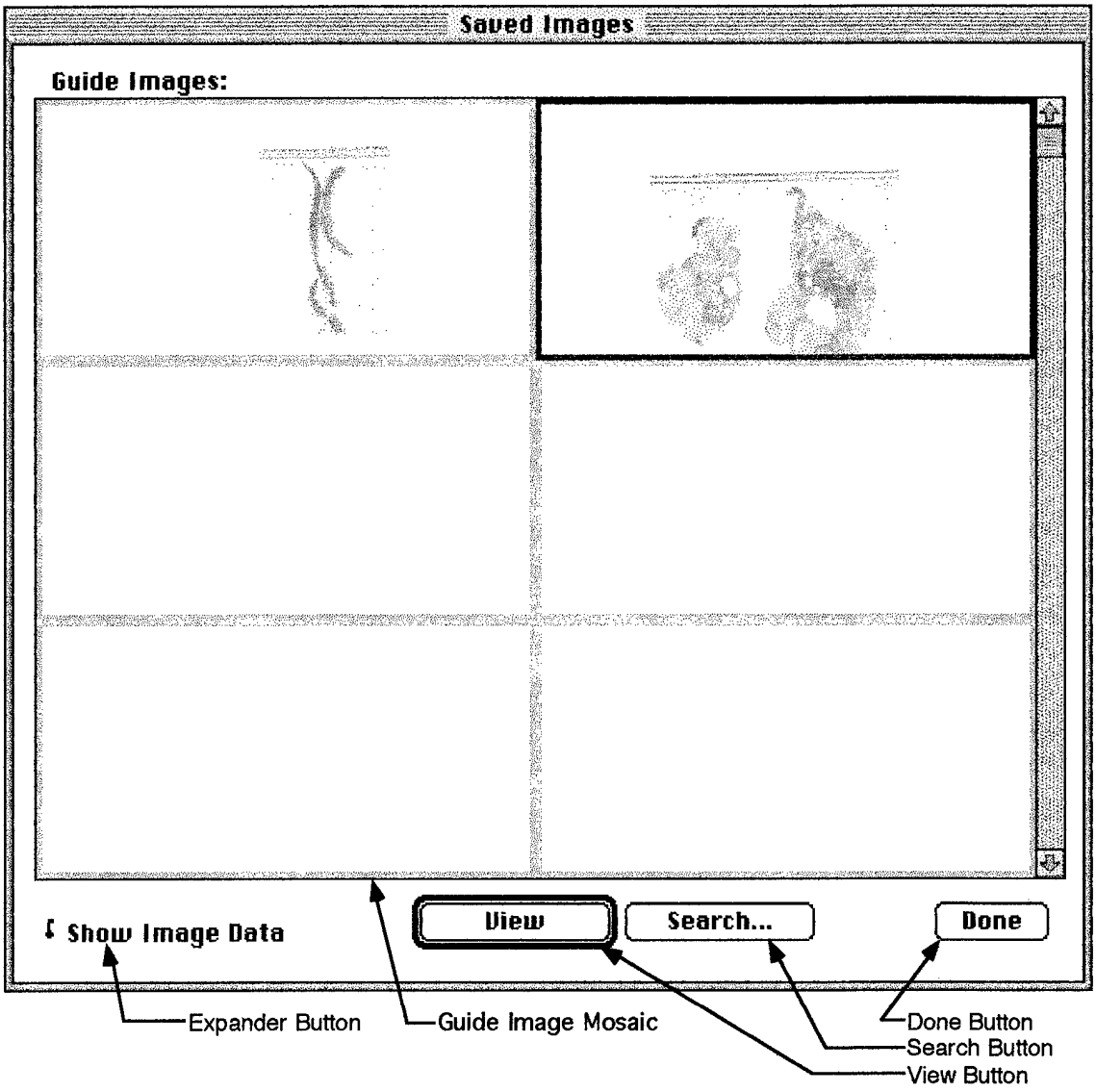
Enter all search criteria in the entry fields. use wild cards as necessary ('*' = multi char, '?'= single char, []= single position string). If no criteria is entered all saved images will be returned. All text searches will be non case sensitive.

2.3.5 Help Button

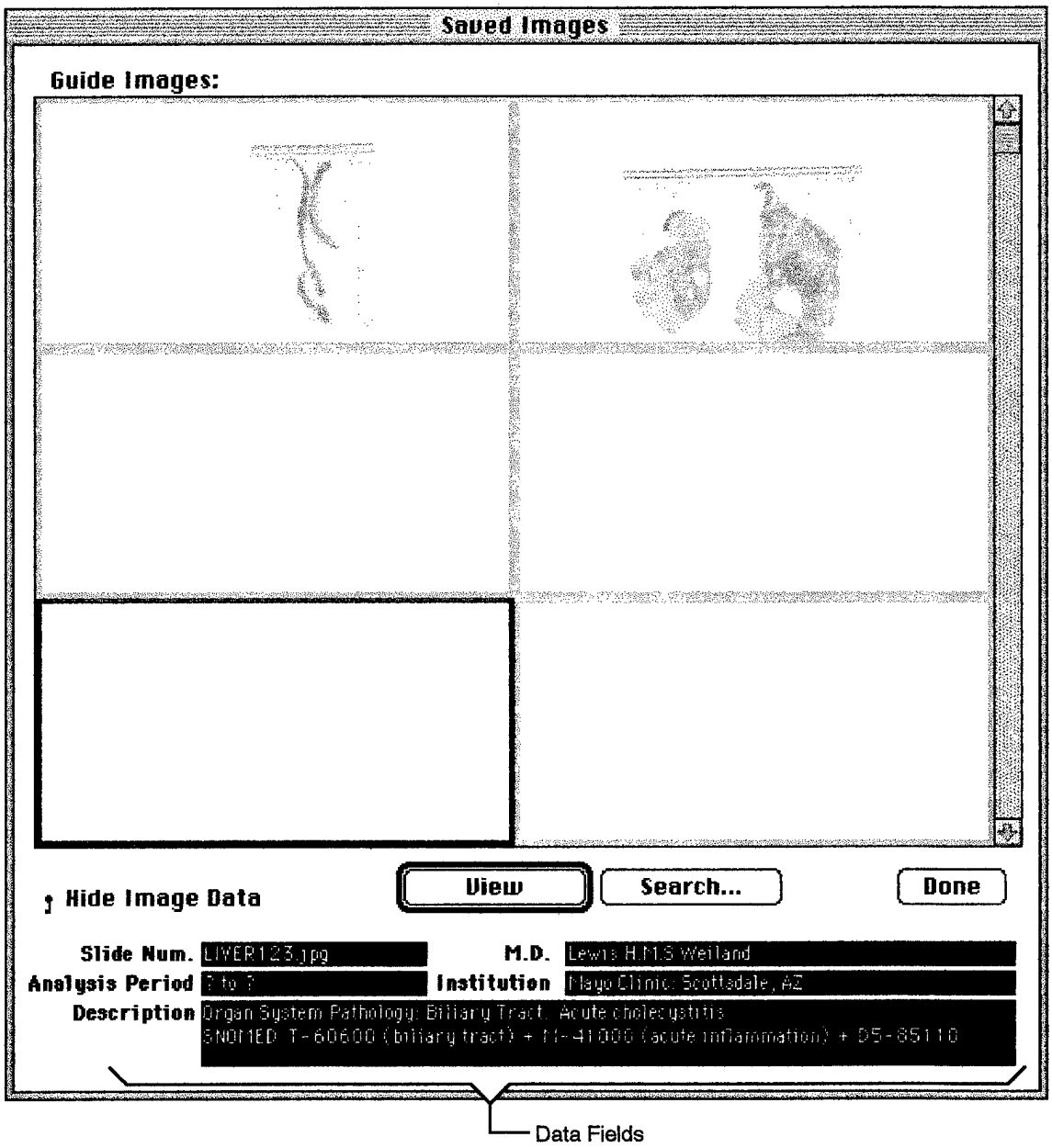
The help button will invoke a help window which will explain the use of wild cards and search criteria.

2.4 Saved Images Dialog

The saved images dialog is a moveable modal dialog which requires a response before the user can continue. Any of the buttons identified below will release the dialog and return to the main window.



Saved Images Retrieval Dialog



Saved Images Dialog in Expanded Mode

2.4.1 Data Fields

The data fields display the image data for the selected image. These fields are view only and will automatically change when the user selects a different guide image.

2.4.2 Done Button

To exit the dialog without selecting a saved image press the done button. This will be the default button if no image is selected.

2.4.3 Expander Button

To view the image data associated with the selected image the user can press the expander button which will resize the window and display the data. When expanded the window can be contracted by pressing the expander button again. The text will change in accordance with the mode of the dialog. The text will also be part of the button (i.e. it "wants clicks").

2.4.4 Guide Image Mosaic

A thumbnail representation of the guide images selected via the search will be displayed in the guide image mosaic. The guide image will also show the high magnification locations as marquees or dots.

2.4.5 Search Button

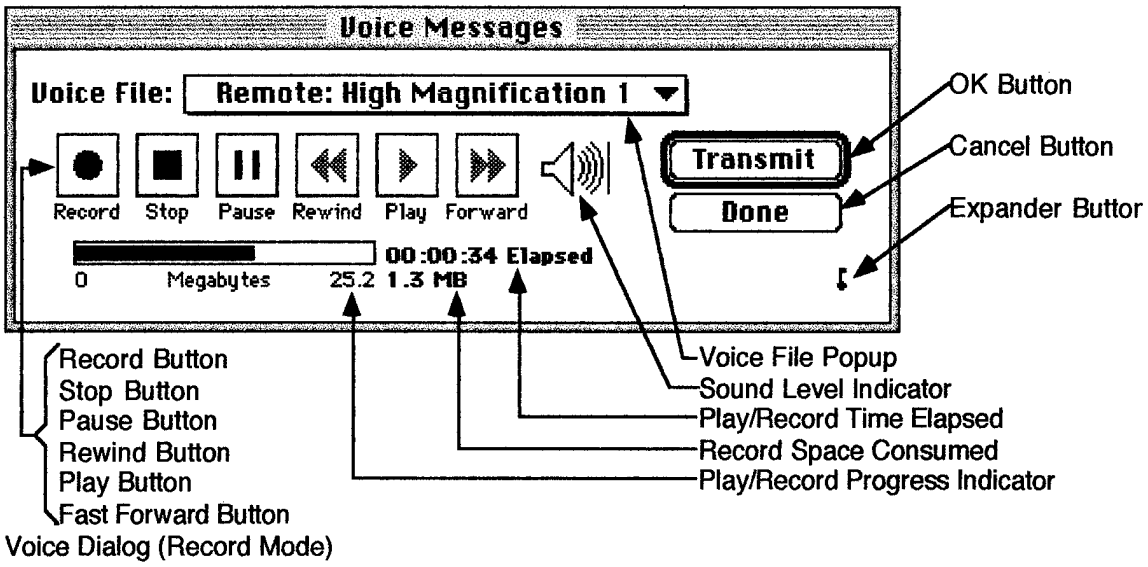
The search button will invoke the database search dialog allowing the user to select a new set of images.

2.4.6 View Button

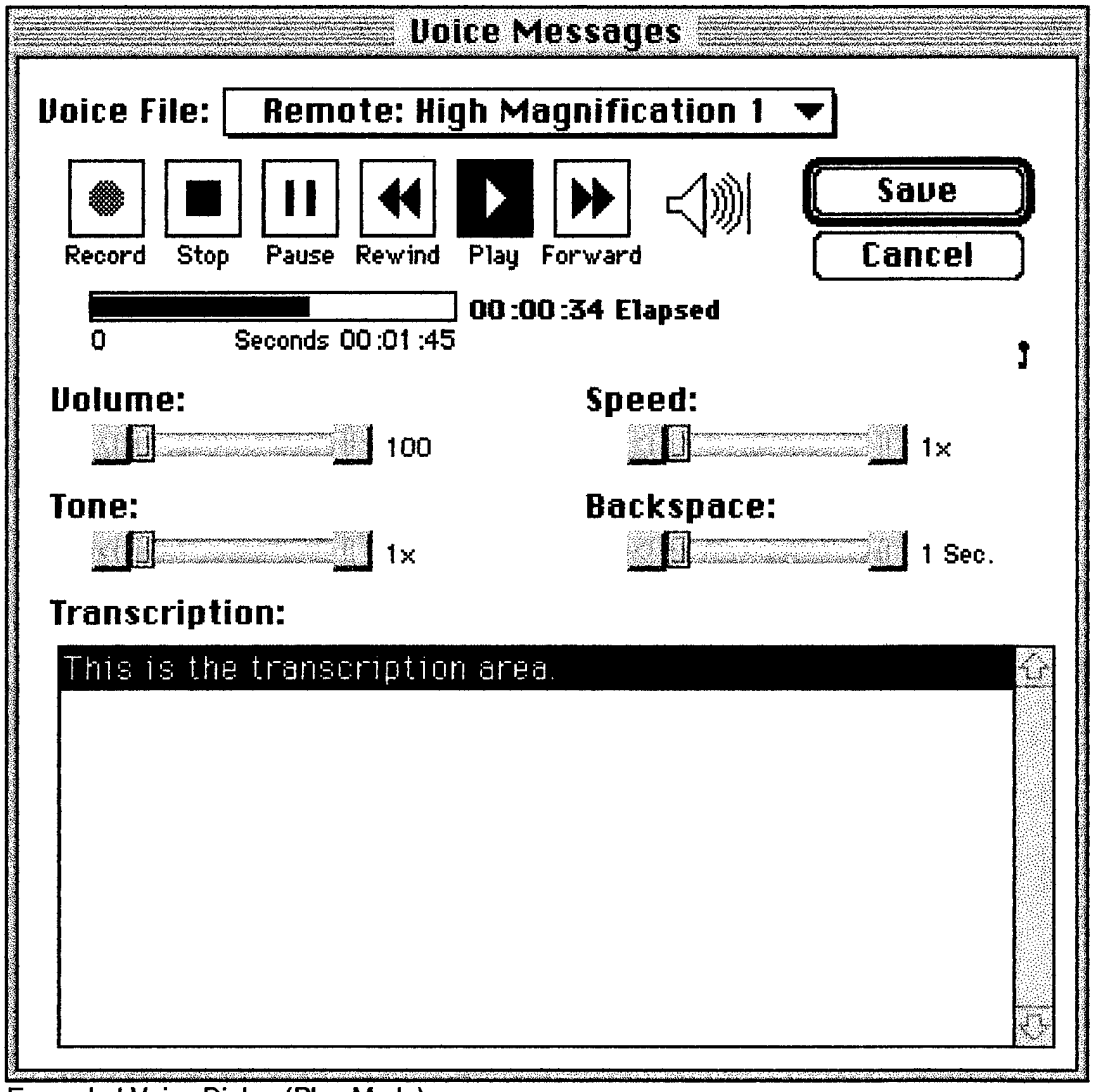
To view an image and its associated high magnification images press the view button. This will release the dialog and return to the main window. The high magnification images stored for the current guide image will be available through the marquees in the main window.

2.5 Voice Dialog

The voice dialog is a moveable modal dialog. The voice that is being played or recorded through the dialog will be associated with the image or location displayed in the main window. This dialog is modeled after the sound addition dialog in the standard Macintosh operating system. Consistency between the standard dialog and the sound dialog in the Pathology Workstation should be maximized. The voice dialog will be utilized by the transcriptionist in expanded mode. The transcriptionist will typically have a foot treadle device which will be connected via the ADB or serial port and will control the fast forward, rewind, pause and play functions of this dialog.



Voice Dialog (Record Mode)



Expanded Voice Dialog (Play Mode)

2.5.1 Backspace Control

The backspace control sets the distance in seconds that will be set behind the current play position when the rewind control is pressed. The control range is from 1 to 10 seconds in 1 second increments. The default setting is 1.

2.5.2 Cancel Button

To release the dialog without saving the sound message to the image file press the cancel button.

2.5.3 Expander Button

The expander button is available during diagnosis transcription. This button expands the voice dialog so that the transcription field can be typed into while the dictated diagnosis is being played.

2.5.4 Fast Forward Button

Fast forward the voice play. This control increments the speed control by one each time it is pressed.

2.5.5 Pause Button

The pause button will pause the play of a sound message. The button acts as a toggle so that play can be resumed by pressing the button again. The pause button will only be enabled during playing of the message.

2.5.6 Play Button

The play button will play the message. The button will be enabled after the message has been recorded or if the user in retrieving a saved message.

2.5.7 Play/Record Progress Indicator

The play/record progress indicator will display the time elapsed as a progress bar during a play session. The max. number will indicate the total time length of the sound byte. During a record session the bar will indicate the ratio of disk space consumed over the space available. The max. number will indicate the total space available on the disk which holds the application.

2.5.8 Play/Record Time Elapsed

The message time elapsed during a play or record session will be displayed in the play/record time elapsed field.

2.5.9 Record Button

To record a new message and save it to the current image press the record button.

2.5.10 Record Space Consumed

The record space consumed will display a running total of the disk space consumed during a record session.

2.5.11 Rewind Button

Rewind the voice play.

2.5.12 Save Button

To release the dialog and save the sound message to the image file press the Save button.

2.5.13 Sound Level Indicator

The relative sound level will be illustrated in the sound level indicator via a series of 5 "Sound Wave Lines". This gives the user an indication of the amplitude of the sound wave.

The Five Sound Wave Lines

2.5.14 Speed Control

The speed control sets the playback rate. The control is initially set to 1 (at the center point of the control) for normal playback. The control has a speed increase range from normal (1x) playback to 8 times normal playback in 12 increments with an exponential base of 2 (ie. from $2^{\wedge 0}$ to $2^{\wedge (12/4)}$). The speed decrease range is equal to the inverse of the increase range (ie. from 1 to 1/8th speed). The default setting is 1.

2.5.15 Stop Button

To stop the recording or playing of the message press the stop button.

2.5.16 Tone Control

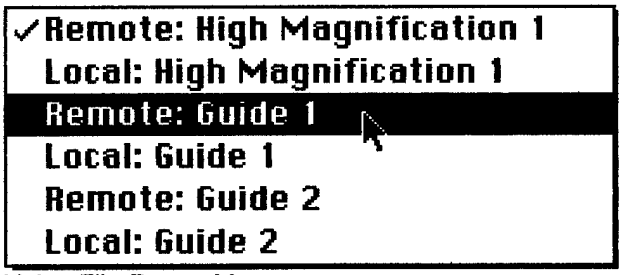
The tone control allows the user to set the tone of the sound. This feature allows the user to adjust the sound pitch so that the voices can be understood at different speeds. The tone is

measured by the amplitude of the sound wave. The scale and range of the control is identical to the speed control. The default setting is 1.

2.5.17 Transcription Field

During transcription this field will be available and capable of receiving keyboard input. As this is a standard Macintosh editing field it will support all of the standard edit features such as Cut, Copy, Paste, and Clear.

2.5.18 Voice File Popup



Voice File Popup Menu

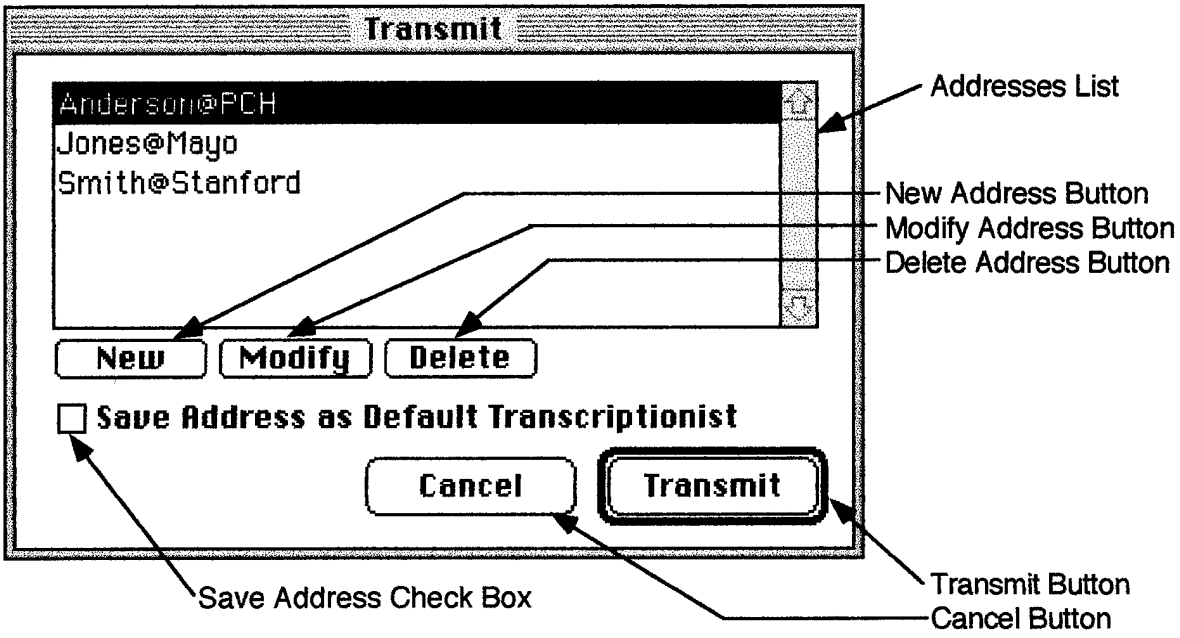
To select a different file for recording or playing the user will choose an item from the voice file popup. This popup allows the user to play the general directions left by the other user (which is associated with the guide image) no matter what the current high magnification location is. The user can also record over or append to the general directions from any high magnification location. The voice file chosen when the user invokes the dialog will be based upon an educated guess as to what the user wants. For example, if the user is at a new location during high magnification creation and has not yet played the voice from the other user then the dialog would naturally choose the "Remote: High Magnification 1" file. However, if the user had already played the voice then the file chosen would be "Local: High Magnification 1". Note that this Local file does not exist yet and if the user does not record voice at the current location then a voice file never gets created, the popup item is simply there to allow the user to create the voice. If the user wants to listen to any voice from previous iterations (should they exist) they would be available in this popup. Of coarse the user can only record to their own station (local or remote) and only to their current iteration. At all other times the files are read only.

2.5.19 Volume Control

The volume control has a range from 0 to 100 in increments of 1. A value of zero represents no sound and 100 represents the current setting of the Macintosh sound control panel. The default setting is 100.

2.6 Transmit Dialog

To send an image request or transmission to another site the user will invoke the transmit dialog. This dialog is a moveable modal dialog.



Transmit Dialog

2.6.1 Addresses List

The address list will display all of the saved remote site addresses. These addresses will be stored in a flat file for easy transportation and modification.

2.6.2 Delete Address Button

To delete the selected address press the delete address button.

2.6.3 Modify Address Button

To add a new blank address or to save the current ad-hoc address press the New Address button.

2.6.4 New Address Button

To add a new blank address or to save the current ad-hoc address press the New Address button.

2.6.5 Save Address Check Box

This check box is only available during a transcriptionist selection session. Otherwise, the check box is hidden. If the user selects the check box then the address will be saved to the preferences file as the current users default transcriptionist.

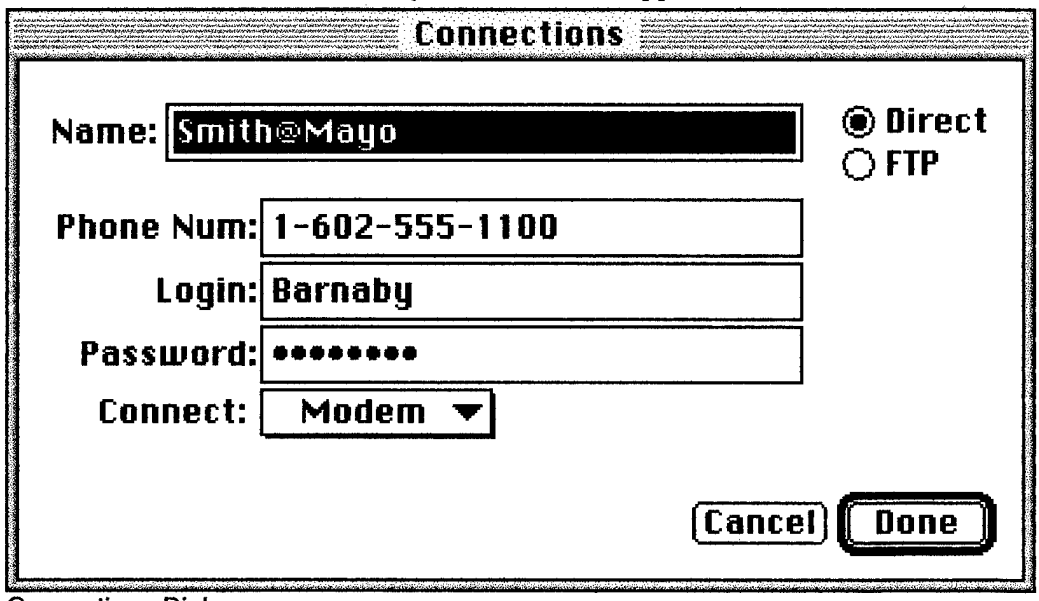
2.6.6 Transmit Button

After selecting the recipient press the transmit button to initiate the transmission object.

2.7 Connections Dialog

The connections dialog will allow the user to name connections and addresses to various remote users. The dialog will be capable of handling many types of communication protocol. The fields and buttons will change according to the protocol chosen so no discussion is given at this time. At a minimum the dialog will be configured to support point to point communication over ISDN. The constants in the dialog are described below.

The communication object (TPWCommunications) will be responsible for handling all communication functions. This includes the sending and receiving of files as well as the transmission of mouse and keyboard activity during chat. All of the functions inside of the communication object will be pure virtual meaning that they must be overridden. This is to ensure that the functionality is provided regardless of the machine or communication type. Currently, the only proposed connection type is ISDN over phone line. Since the development is being done on the Macintosh it is planned that the communications be maintained using Open Transport. Open Transport is currently a set of INIT's which will eventually become a standard part of the Mac OS. Open Transport provides all of the communication functionality which will be required by the TPW and continues to add connectibility for other connection types. For more information on Open Transport reference the documents currently available from Apple.



Connections Dialog

2.7.1 Cancel Button

Discard the changes to the connection.

2.7.2 Done Button

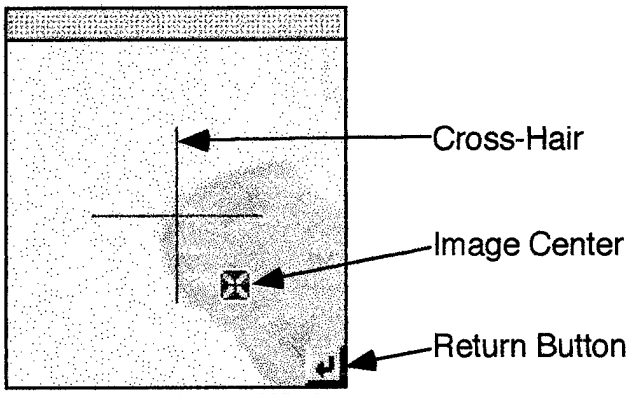
Accept the changes to the connection.

2.7.3 Name Field

Enter a meaningful name for the recipient.

2.8 Guide Image Floating Window

The guide image floating window is only available during high magnification creation. The window displays an image 256x256 pixels. The cross will always indicate the center of the current high magnification location so that the user can easily navigate.



Guide Image Floating Window

2.8.1 Cross-Hair

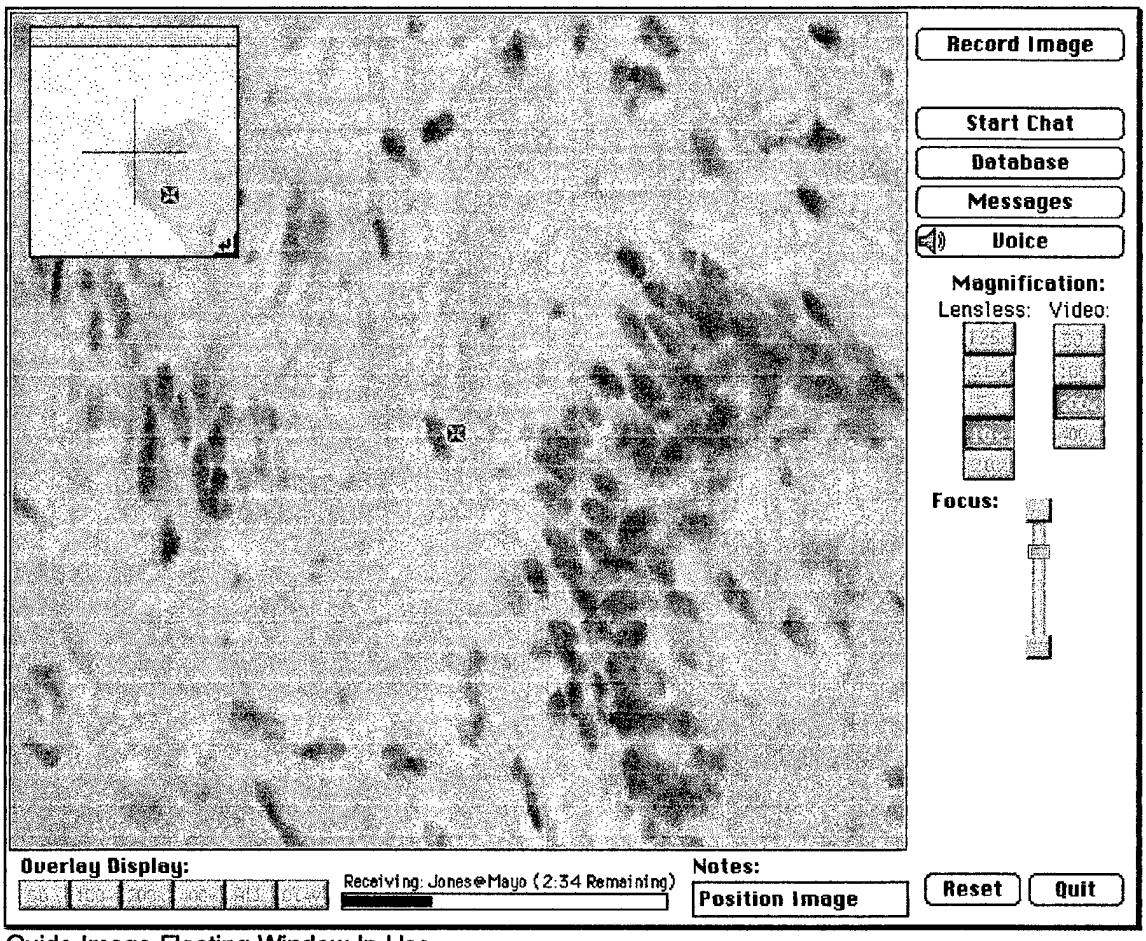
The cross-hair is always in the center of the floating window which always displays the image at the center of the remoter users request. The cross-hair indicates the center of the requested location from the remote user.

2.8.2 Image Center

The image center indicates the center of the users current location in the main window high magnification image display.

2.8.3 Return Button

The return button will reposition the user at the location of the requested high magnification image. If the user is at the exact location of the request the button will be disabled.



Guide Image Floating Window In Use

2.9 Database Entry Dialog

The database entry dialog will be available after all dictated diagnoses have been transcribed and before the diagnosis information is saved to disk.

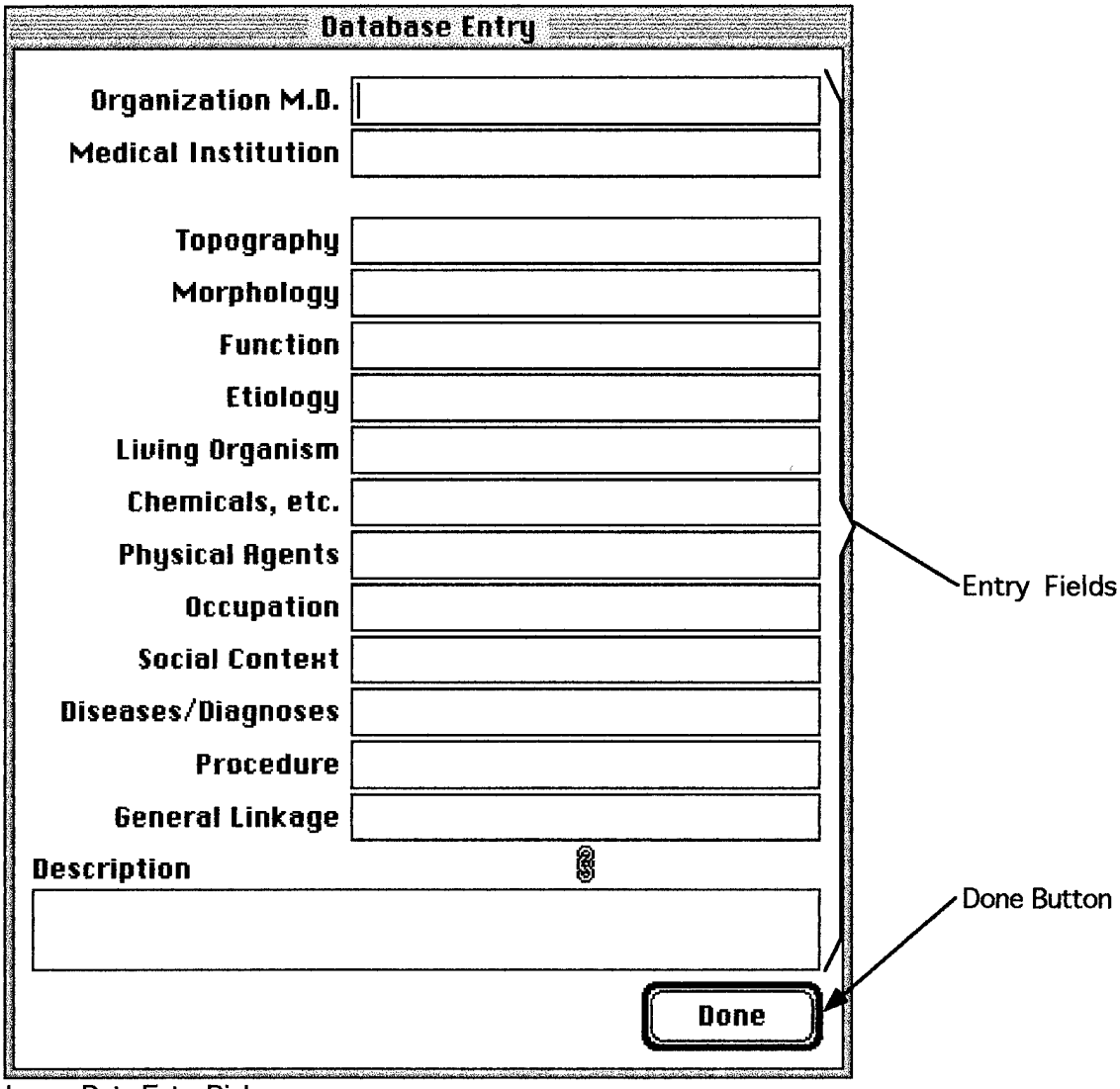


Image Data Entry Dialog

2.9.1 Done Button

The only button available is the done button. This is the only screen which allows the user to enter this information and the user only has one chance at it. It is therefore not desirable to have a cancel button for the user to avoid entry.

2.9.2 Entry Fields

All data will be entered through the entry fields. The MD. and Institution fields are simply entry fields. The Topography through Occupation fields (SNOMED generators) are actually tied to the SNOMED Code field. When a value is entered into one of the SNOMED generators the appropriate entry into the SNOMED code field is automatically made. Likewise, when the SNOMED code field is edited the corresponding generator field will be automatically updated.

2.10 Image Data Floating Window

The image data floating window is only available during database mode, and only when the main window is the top window. The window displays the image data for the selected image. The window is not closeable because their is no mechanism for re-opening it. It can always be moved out of the image view and is short enough to fit under the view unobtrusively.

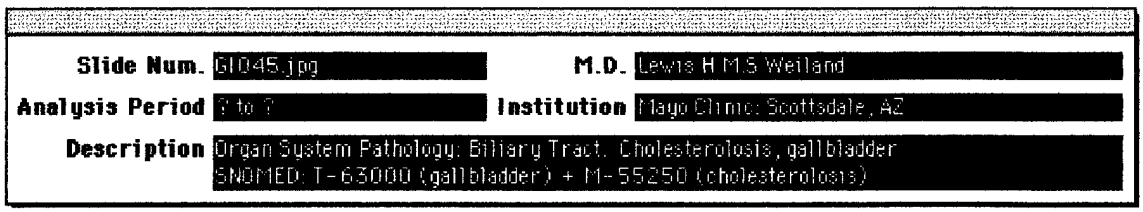
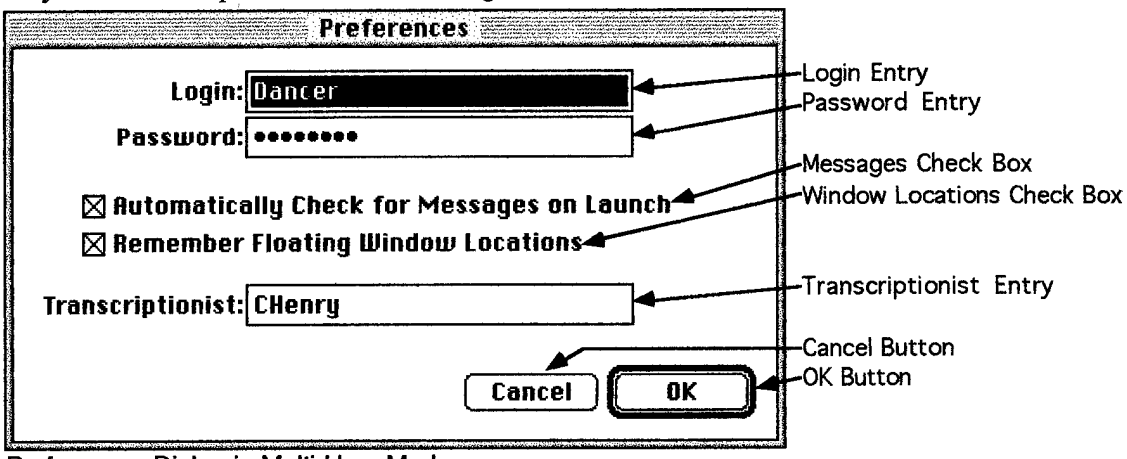


Image Data Floating Window

2.11 Preferences Dialog

The preferences dialog is accessed by opening the preferences file which will be in the same folder as the application. The user can open the file whether the application is currently running or not. If the application is not currently running then it will be launched. Currently the only preferences which have been identified is the ability to change or delete the saved password. As other preferences are identified during the development process they will be incorporated into the dialog.



Preferences Dialog in Multi User Mode

2.11.1 Cancel Button

To discard all changes to the preferences dialog during the current session the user presses the cancel button.

2.11.2 Login Entry

If the system is in single user mode the user can change their login name in the login entry.

2.11.3 Messages Check Box

The user sets the messages check box on in order to have the system automatically prompt for message response on system launch.

2.11.4 OK Button

To save all changes to the preferences dialog during the current session the user presses the OK button.

2.11.5 Password Entry

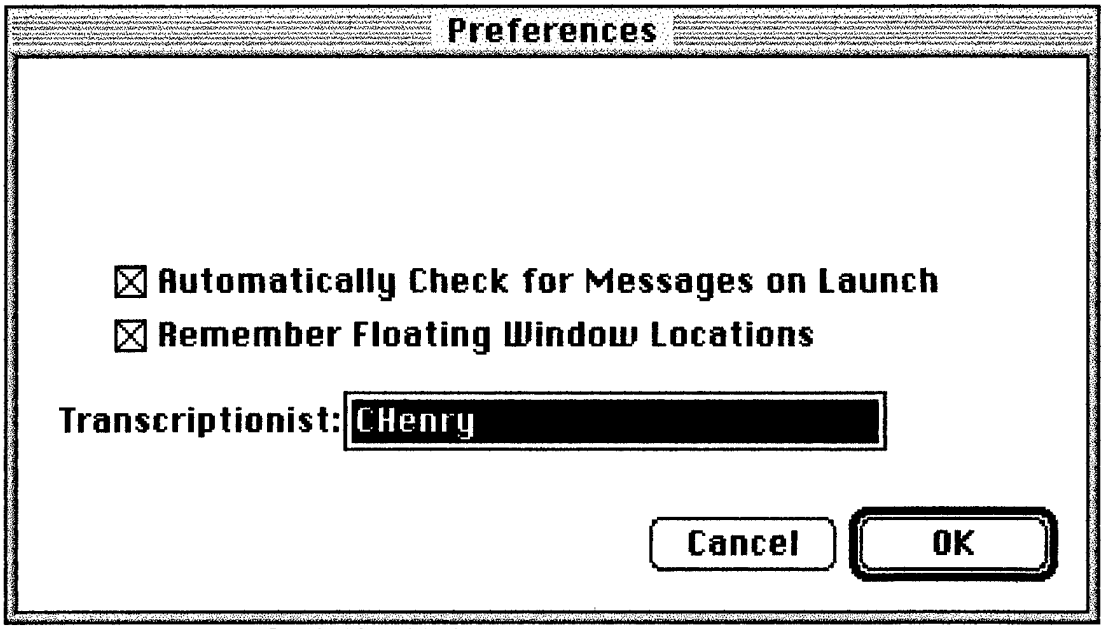
If the system is in single user mode the user can change their password in the login entry.

2.11.6 Transcriptionist Entry

The user can select a new transcriptionist or delete the current one (thus requiring a selection each time the diagnosis is sent) in the transcriptionist entry field.

2.11.7 Window Locations Check Box

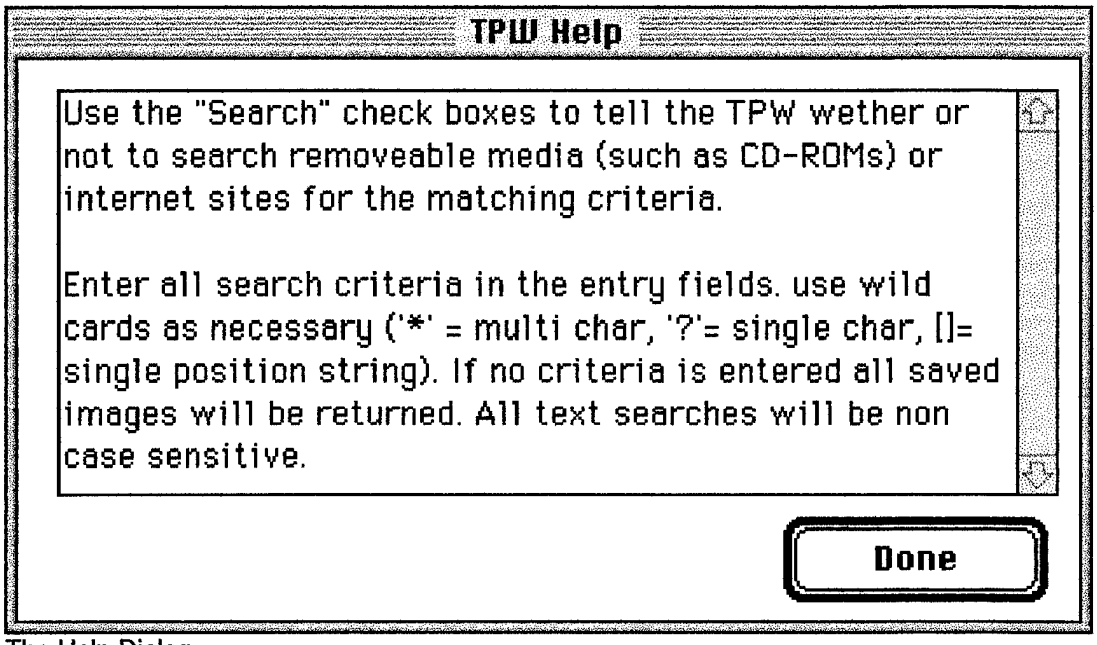
In order for the floating window locations to be saved from session to session the user will check the window locations check box.



Preferences Dialog in Single User Mode

2.11 Help Dialog

The help dialog is currently invoked only from the database search dialog.

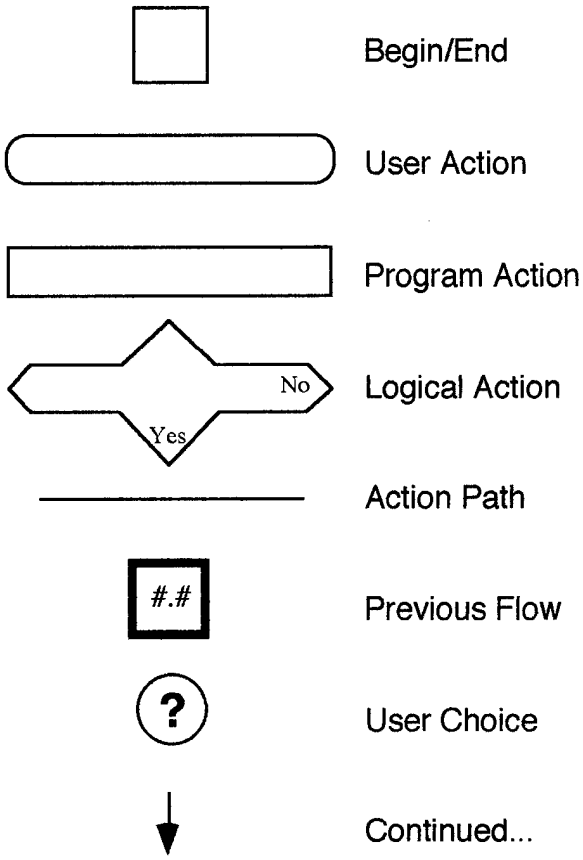


The Help Dialog

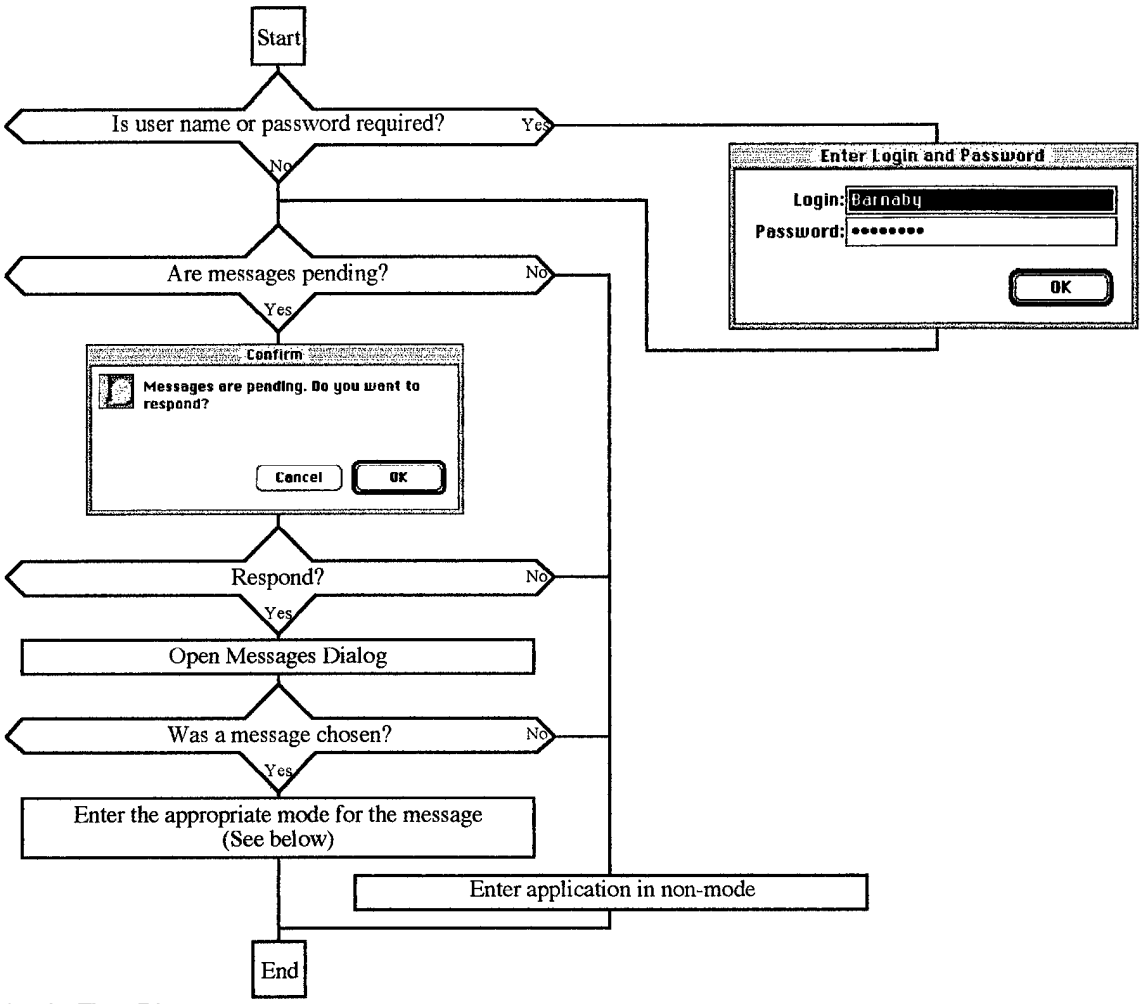
3 USER SCENARIOS

The following scenarios outline the common Tele-Pathology user scenarios from a graphical and procedural stand point. For the purpose of this discussion the Local User will be known as the user who possesses the physical specimen slide in a dual station scenario, and the Remote User is the person who has access to the slide only through the generated images.

Legend

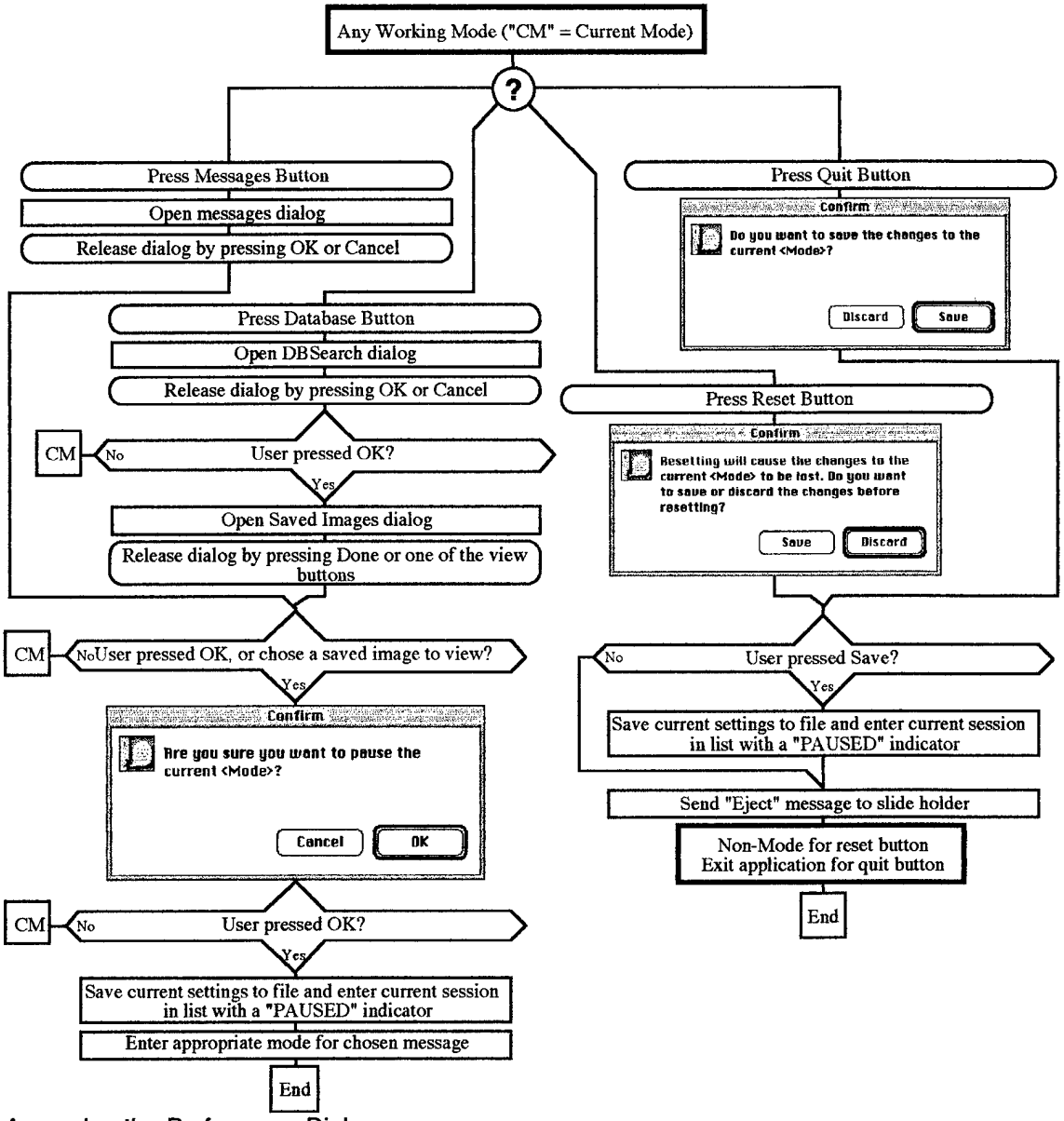


The following scenario depicts the login events. In this scenario the user has launched the application and will be prompted for appropriate actions.



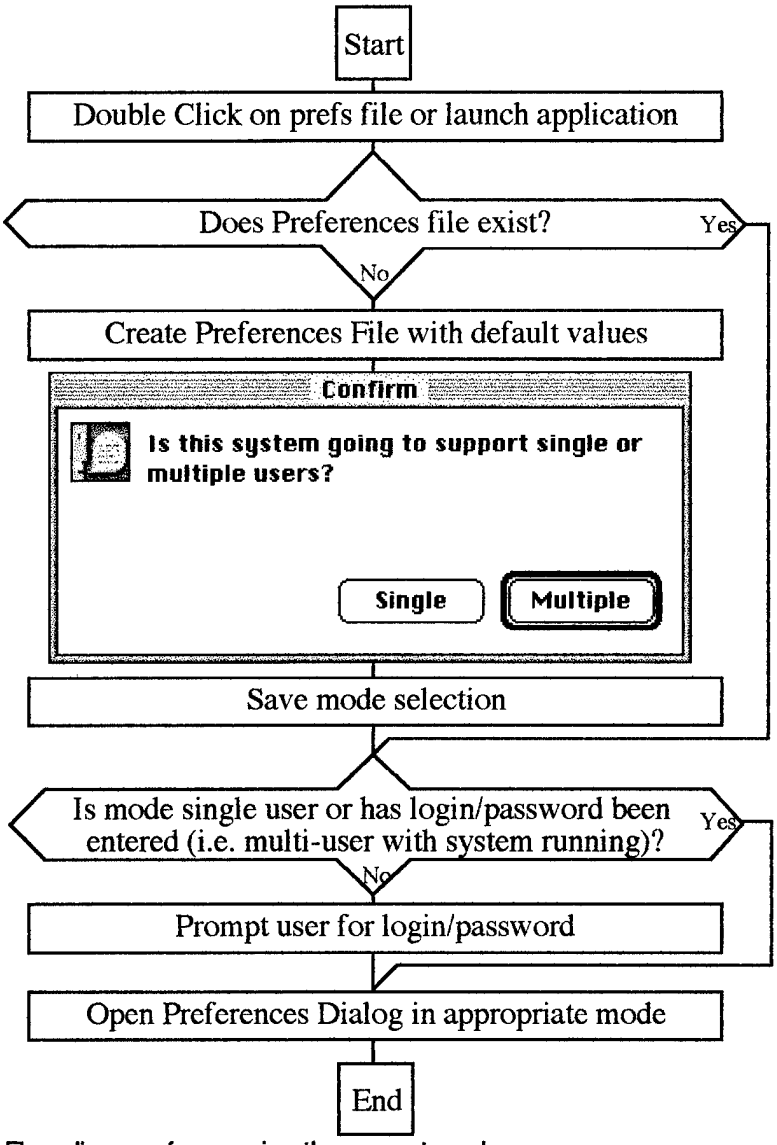
Login Flow Diagram

Another potential startup scenario is that of double clicking on the preferences file or launching the application when the preferences file does not exist (or cannot be found). Either of these two cases can be used to get to the preferences dialog and save preferences. By looking at the following diagram the reader can quickly identify that the only way in which a system can be changed between single and multi user is to throw away the preferences file (or if the user is familiar with the preferences file format, by editing it directly).



Accessing the Preferences Dialog

During any of the working modes the user could choose an action which will require either saving and pausing the current scenario or discarding the changes. The working modes consist of: Create Guide, Request High Magnification Images, Create High Magnification Images, Generate Diagnosis, and Slide Examination. The actions which may initiate this flow are: pressing the messages button (if messages are available), pressing the database button, pressing the reset button, pressing the record button if the user is in create guide mode, or pressing the quit button. If the user chooses one of these actions then they will be prompted for a decision to put the current mode on pause.



Flow diagram for pausing the current mode

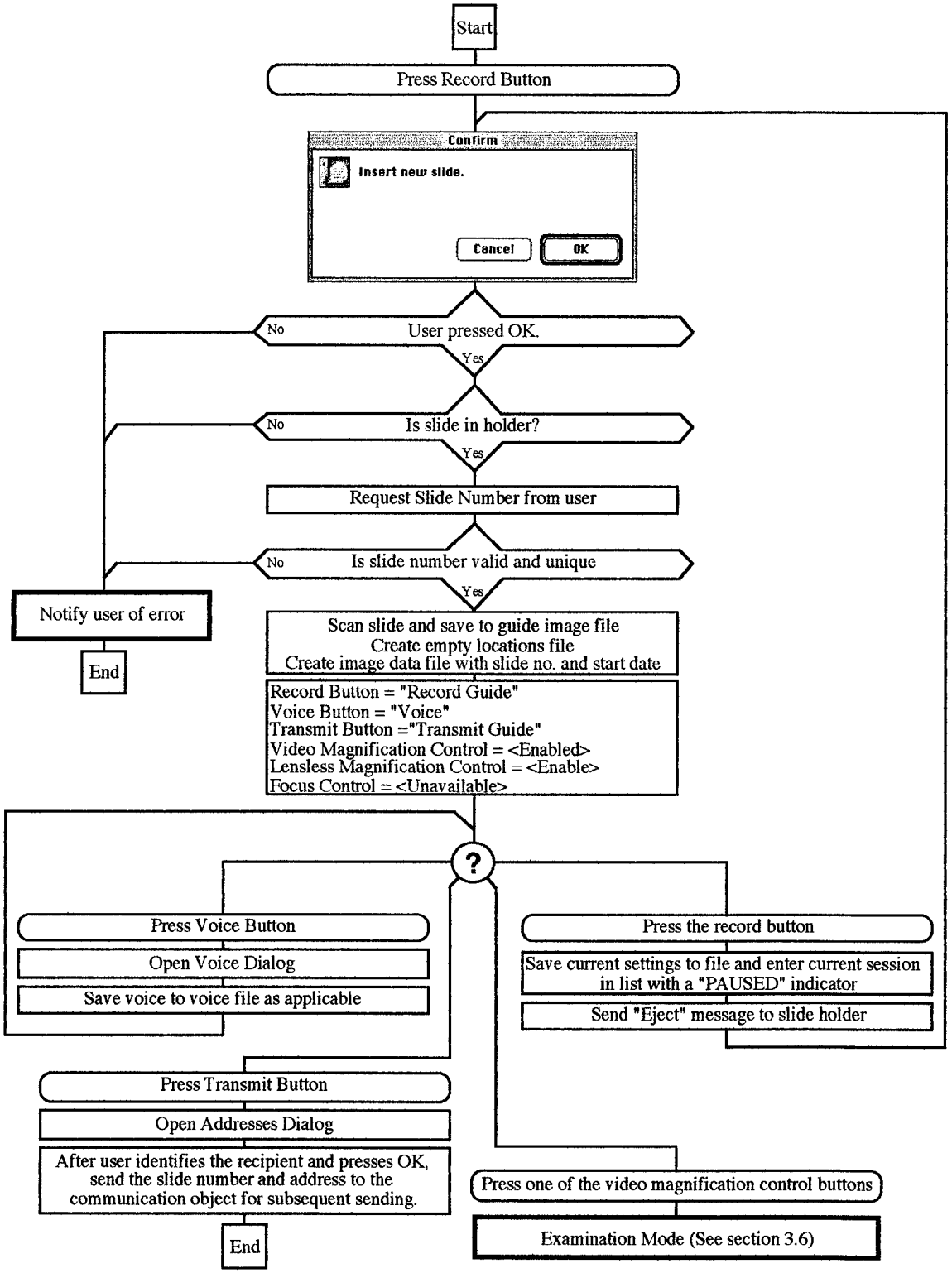
The user can also pause the current mode by entering a chat (see section 3.8) or by quitting the application.

All following scenarios assume that the application is currently running. In each of the scenarios the indication of the "End" means that the user enters non-mode. In this mode the control states are as follows:

Record Button	"Record Guide"
Voice Button	<Unavailable>
Transmit Button	<Unavailable>
Video Magnification Control	<Unavailable>
Guide Magnification Control	<Unavailable>
Focus Control	<Unavailable>

3.1 Dual Station, Local User - Generate Guide Image and Transmit

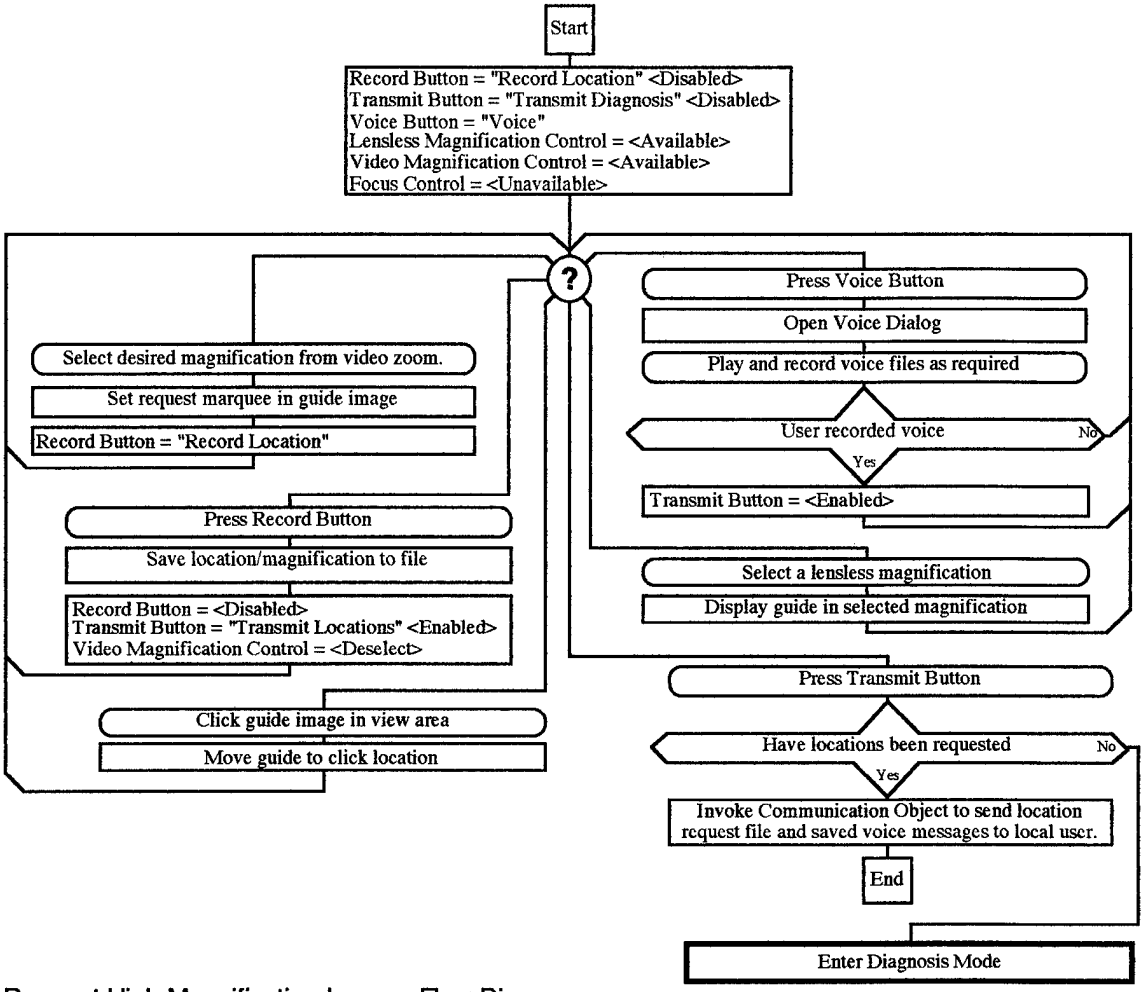
The local user begins by loading the slide onto the table and pressing the record button which reads "Record Guide". The system then prompts the user for the slide number and scans the slide at 1x magnification. If a slide is not on the table or an invalid slide number is entered the system displays an error and no Mode is activated. At any time the user could press the voice button to store a voice message with the image. After recording the image and optional message the user presses the transmit button and chooses a recipient from the transmit dialog. The session is concluded with the successful transmission of the image to the remote user.



Create Guide Image Flow Diagram

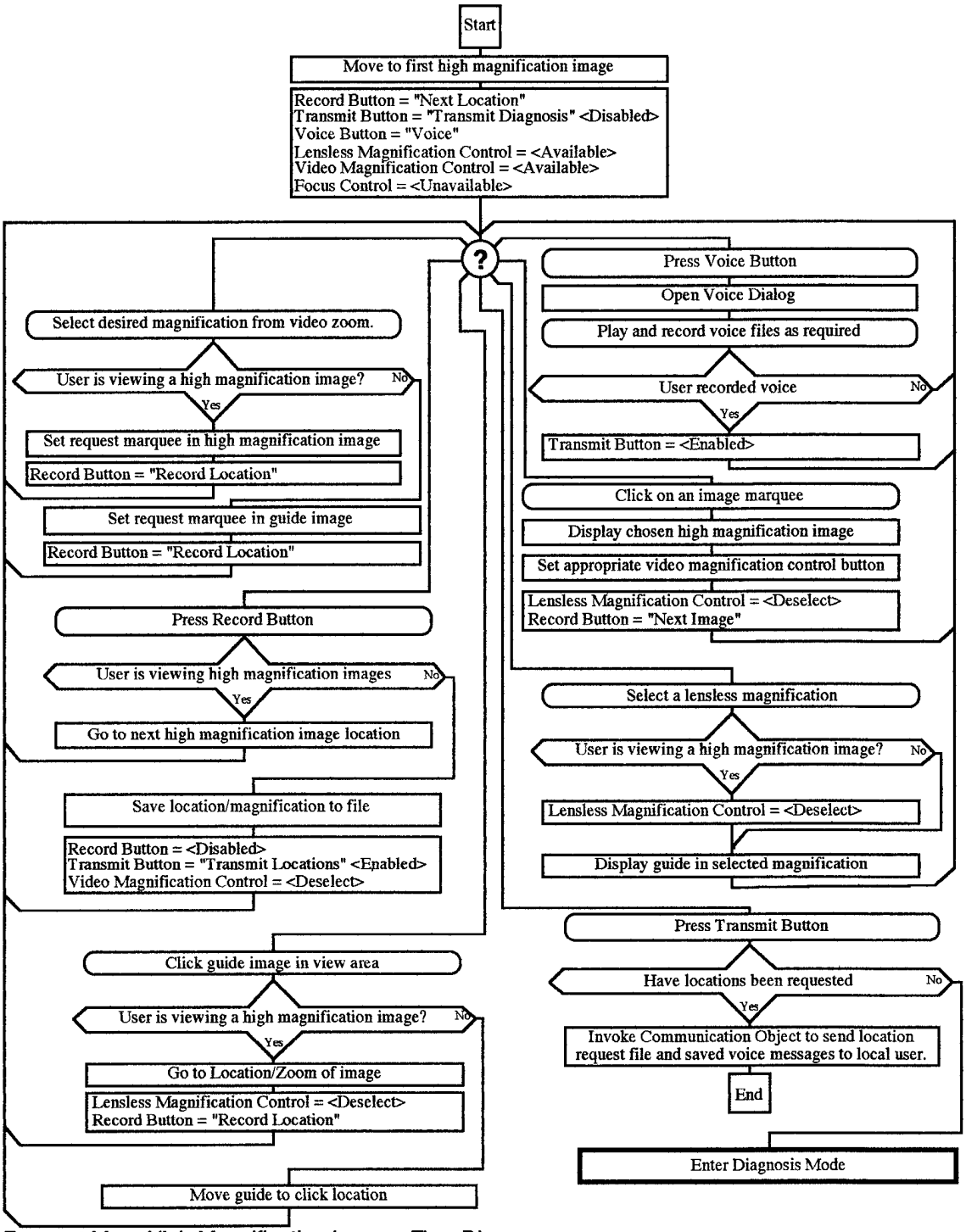
3.2 Dual Station, Remote User - Request High Magnification Images

The remote user will notice a message in the message list indicating that a guide image has been received and analysis requested. The user can either double click on the message or press the respond button. The user will now be in the request high magnification images mode. The user will review the image on screen and choose locations for high magnification analysis by pressing the record button (titled "Record Location"). Before pressing the record button the user will have positioned the area of interest in the center of the view and chosen an appropriate magnification with the video magnification control. The view will display a floating dotted rectangle (marquee) indicating the area of the image which will be captured by the camera when the high magnification image is created. The user can select a magnification from the guide magnification control at any time to see more or less of the guide image. The marquee will adjust according to the users position and magnification. Once the user presses the record button the dotted rectangle will fix to the guide and be added to the locations list. The video magnification control will un-depress and the floating rectangle will disappear until the user chooses another high magnification setting. The user can review any requested location/magnifications by double-clicking on its marquee number in the guide display. When a location is selected for review the dotted line and magnification will be set and the record button will read "Remove Location". As soon as the user scrolls the image the record button will again read "Record Location" and the video magnification control will be un-set. The record button will only be activated if the video magnification is set to something. At any time the user can attach a voice message to a location by choosing the location and pressing the voice button. If a location has already been associated with a voice message the user will be able to play the message or record over it. If the user creates a message at any time that the video magnification is un-set this message will be attached to the session in general as opposed to attaching to a specific location. Each requested locations center point within the guide image and magnification will be stored in a flat file. After all locations of interest have been identified the user will transmit the request file and messages to the local user by pressing the transmit button. This action will always return the file to the same local user which sent the guide image.



Request High Magnification Images Flow Diagram

The following diagram illustrates the scenario when the user has requested images, received them, reviewed them and is now requesting more images.



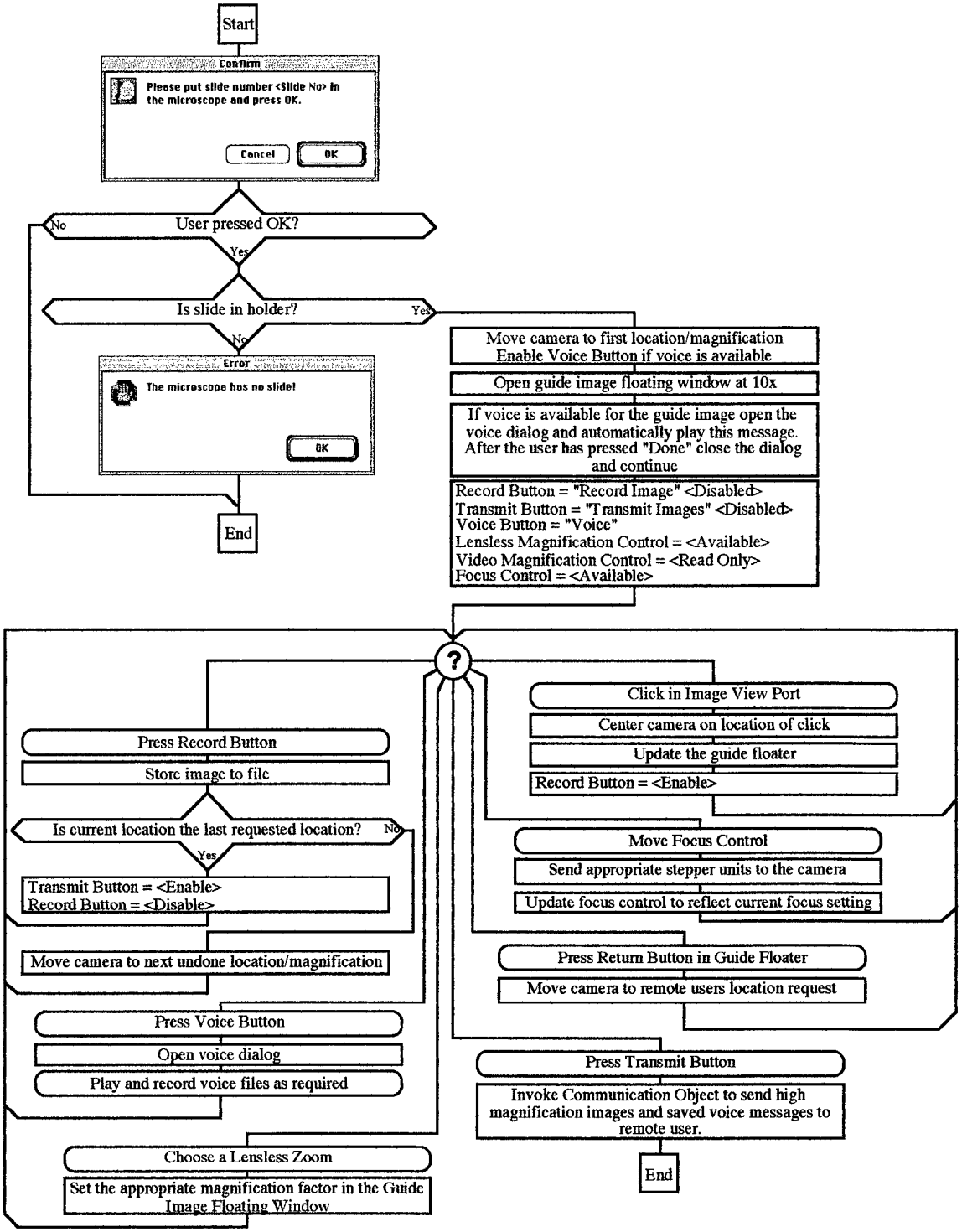
Request More High Magnification Images Flow Diagram

3.3 Dual Station, Local User - Generate High Magnification Images

After the message has been received by the local user the message list will display a notification that high magnification images have been requested. To respond to this message the local user will select the item and press the respond button. The system will then request the slide number and after successfully retrieving the guide image, checking for a valid slide number and ensuring that the slide is on the table will take the user to the "Create High Magnification Images" mode. Each of the location requests will be indicated by a cross which will disappear after the user creates the image. During high magnification image creation the user will have a floating window which will display the current location request at 10x initially. The view window will contain the image at the requested magnification.

The user will automatically be taken to the first location/magnification request and be allowed to pan and scroll and set the focus before pressing the record button. At each location the camera will be automatically magnified and the position scrolled according to the request. The focus will be automatically set to maximize contrast. The user can listen to any messages from the remote user by pressing the voice play button. Before pressing the record button the user can save a message for the remote user by pressing the voice record button.

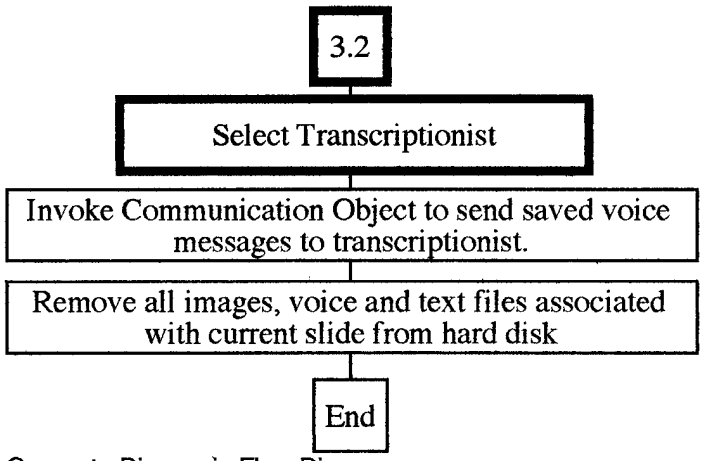
After pressing the record button the user will be taken automatically to the next location. The cross will also dim to signify to the user that the location has been completed. During the entire scenario the transmit button will be disabled until the user records the final image. After pressing the transmit button the images and messages will be sent to the remote user who requested the images.



Create High Magnification Images Flow Diagram

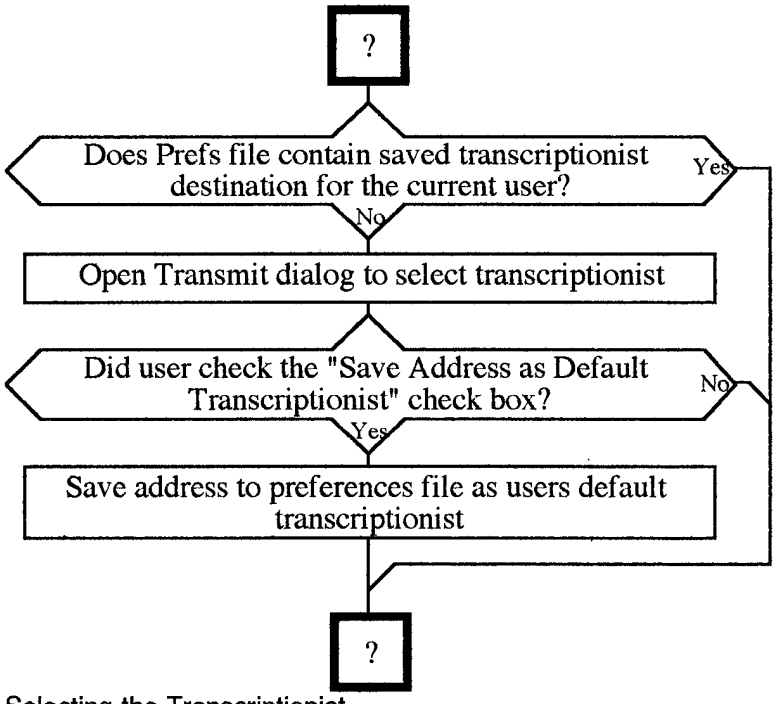
3.4 Dual Station, Remote User - Diagnose From Images

The messages list will notify that the high magnification images have been received from the local user and are ready for analysis. The record button will allow the user to step through the images by acting as a next button (record button is titled "Next Image"). The user can also move from location to location by clicking on the marquee numbers. The user can listen to messages left by the local user by pressing the voice play button. During the viewing of high magnification images the voice record button will invoke the voice dialog for the remote user to dictate a diagnosis associated with the current image. The user moves to the guide by selecting a magnification from the guide magnification. The diagnosis dictation will be sent for transcription to the transcriptionist when the user presses the Transmit button.



Generate Diagnosis Flow Diagram

The following flow diagram illustrates the procedure in selecting the transcriptionist

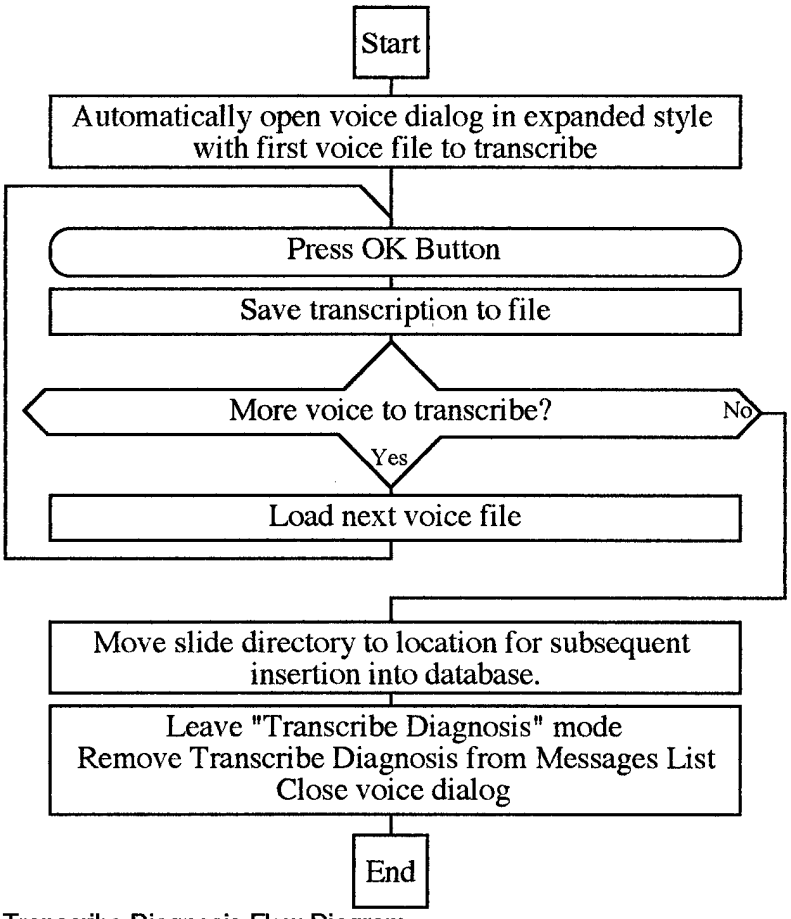


Selecting the Transcriptionist

3.5 Dual Station, Local User - Transcribe Diagnosis

After receiving the dictated diagnosis from the remote user the local user will review the messages and have them transcribed into a text file to be stored with the images. The transcribed voice file will contains section headers indicating the location/magnifications where the diagnosis was made. These headers will be automatically inserted via the transcription process.

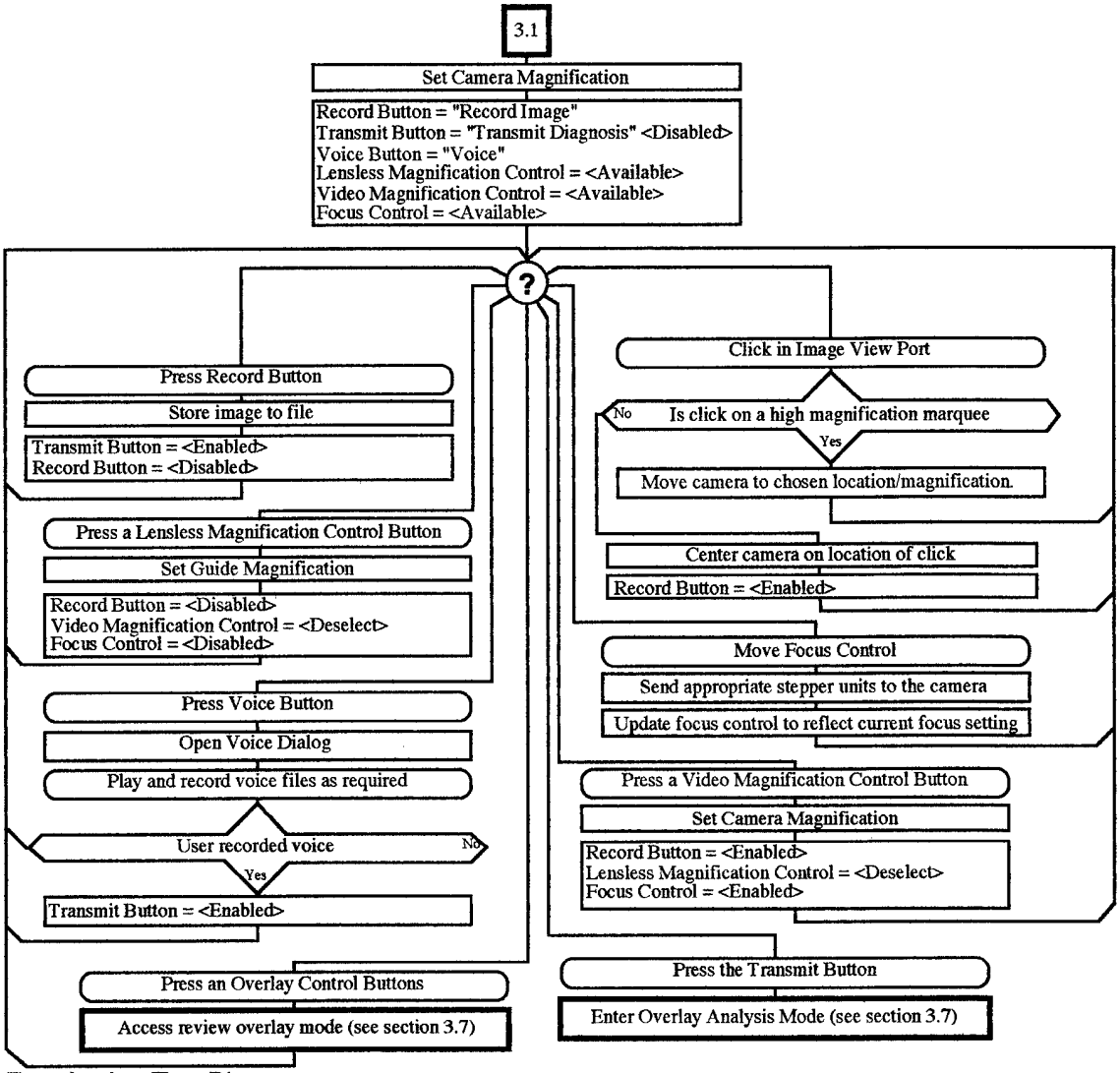
To transcribe the message the local user will select the transcription request from the message list and press the respond button. The user will be automatically taken to the voice dialog in expanded mode with the first diagnosis. When the voice dialog is expanded the text entry will always be live so that the user can press play, pause or stop without losing the current position in the text. During play of the message the text entry will be live so that the local user can type and listen at the same time. After the current dictation is transcribed the user presses the save button (reading "Next") and is automatically taken to the next dictation. After having transcribed all messages and pressing the save button the system will prompt the user for database information and automatically terminate the session by saving the diagnosis and image data to file.



Transcribe Diagnosis Flow Diagram

3.6 Single Station - Examination

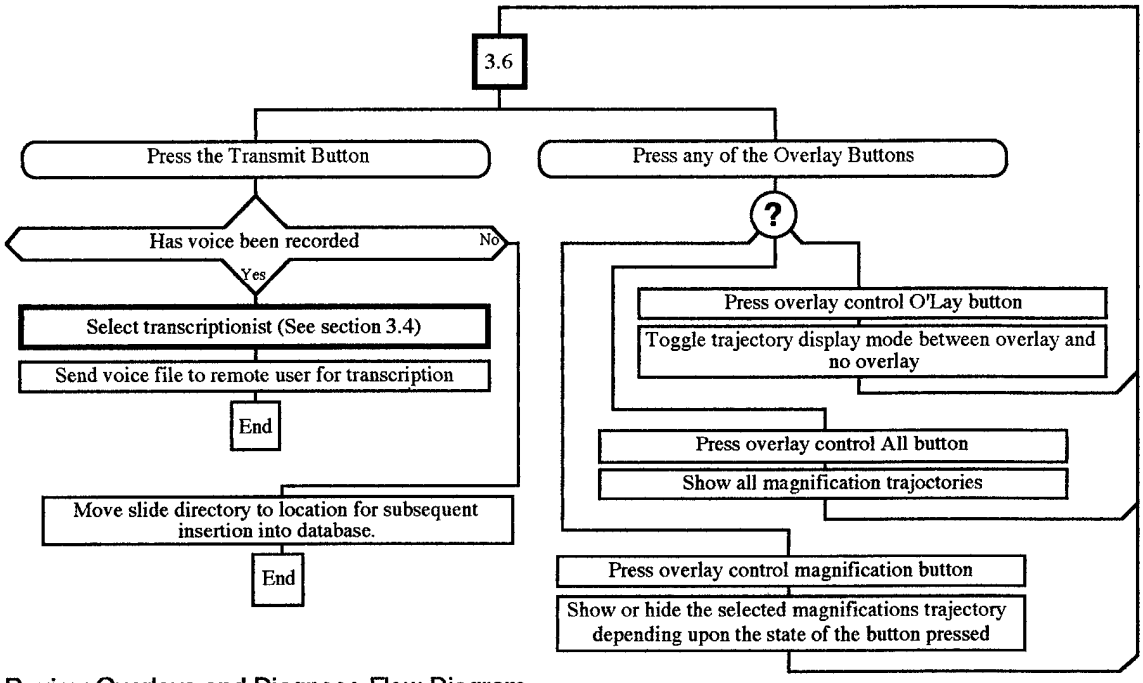
In the final two creation scenarios the local user is also the expert so transmission is not necessary. The user reviews the slide at any location and magnification desired and records images and/or voice at chosen locations. The overlay is stored in a high magnification image request file which logs the location and the magnification of the regions of interest. The locations file stores each and every location/magnification which the user traverses. The file makes note of any locations at which the user records a high magnification image. The user reviews their overlay by pressing one or more of the overlay buttons.



Examination Flow Diagram

3.7 Single Station - Review Overlays and Diagnose

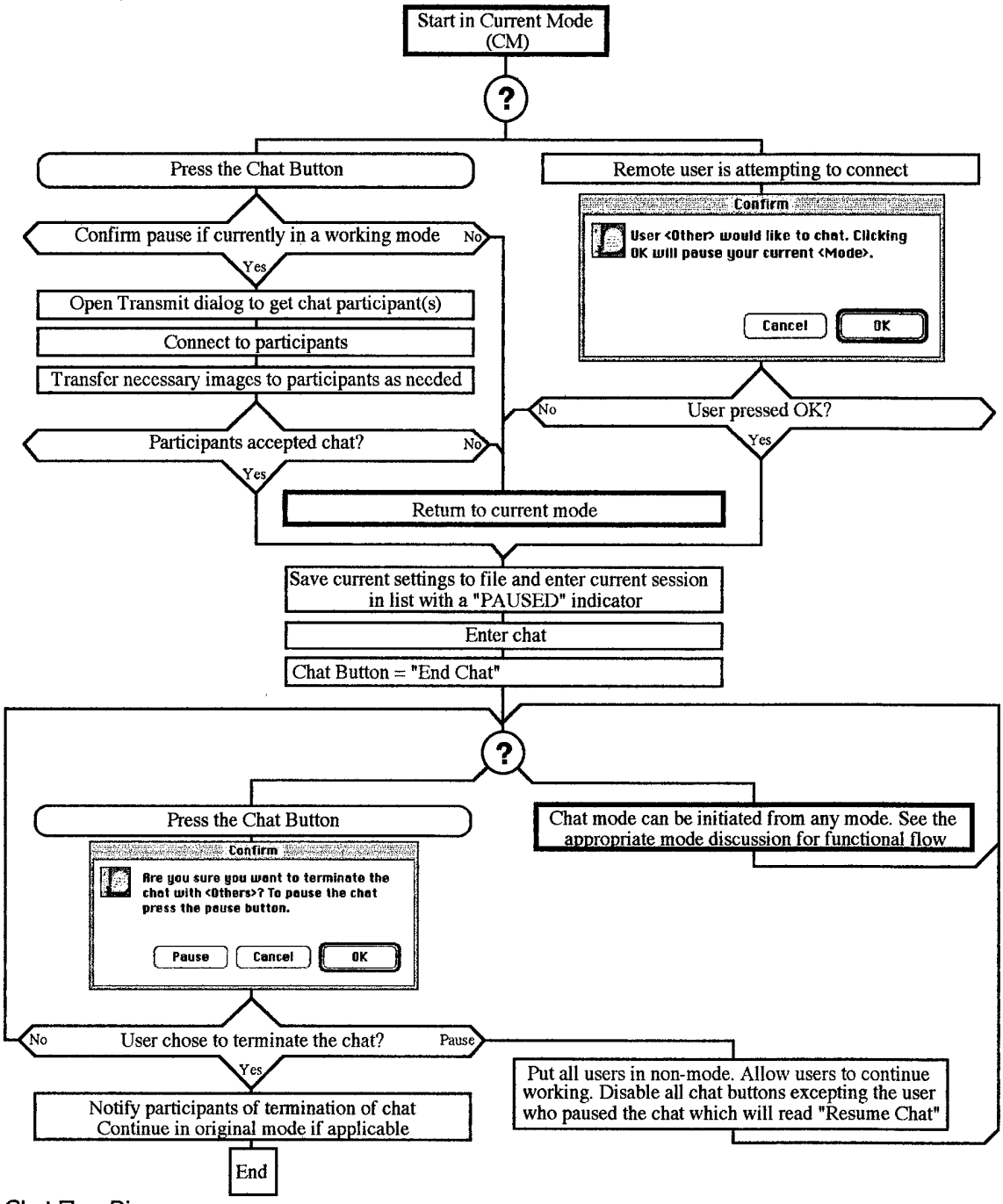
After having traversed the slide as needed the user can review the overlays and dictate a final diagnosis. This diagnosis will then be transcribed and stored along with the images at each location under scenario 3.5.



Review Overlays and Diagnose Flow Diagram

3.8 Dual Station - Chat

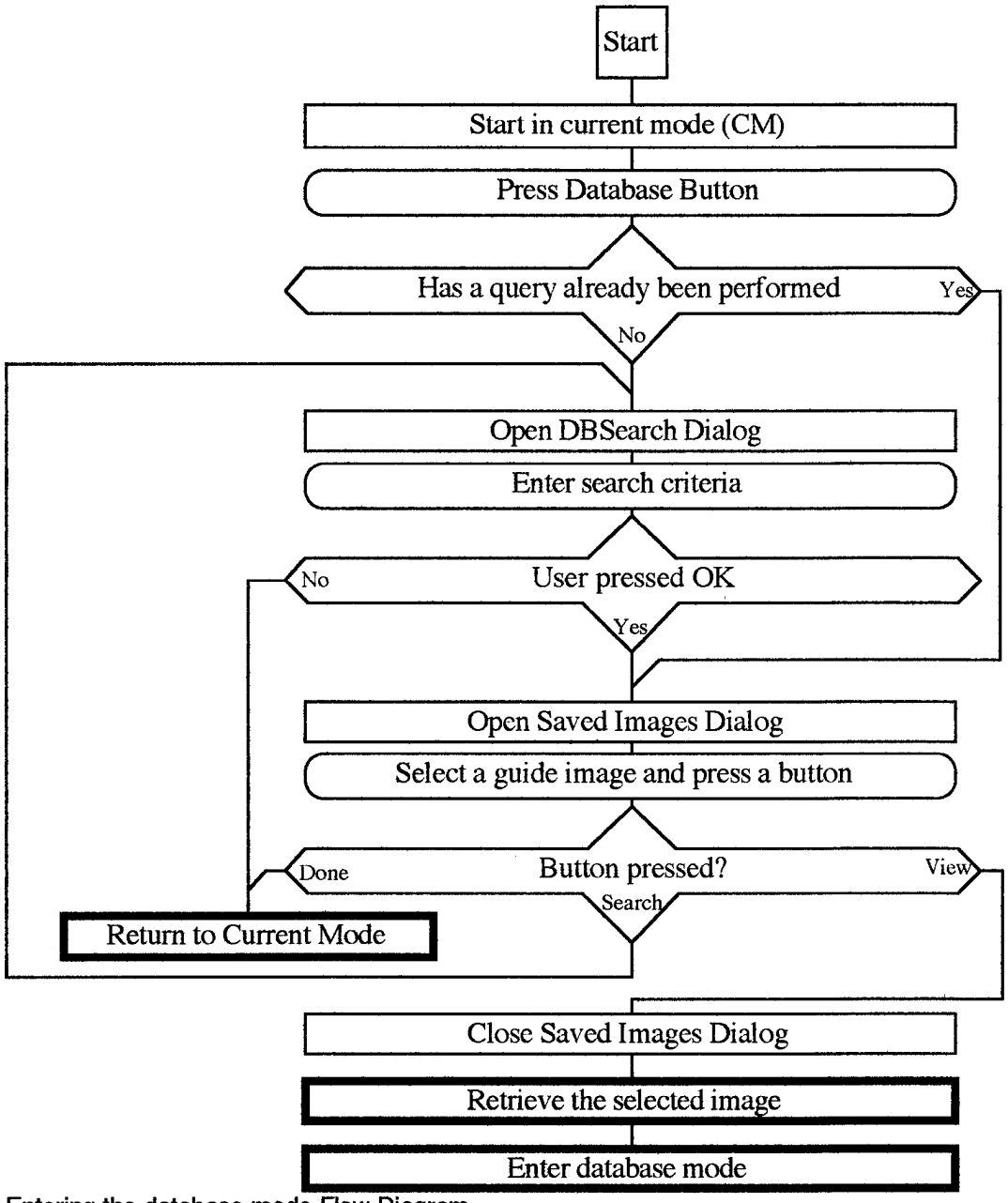
During any image review session (either guide or high magnification) the user can request a chat with a remote user. This is done by pressing the chat button. During this chat session the users will share the mouse and will be able to converse over the standard Macintosh sound channels. At the time of this writing the intended vehicle for implementing the chat is Open Transport (See section 2.7 for a description of Open Transport).



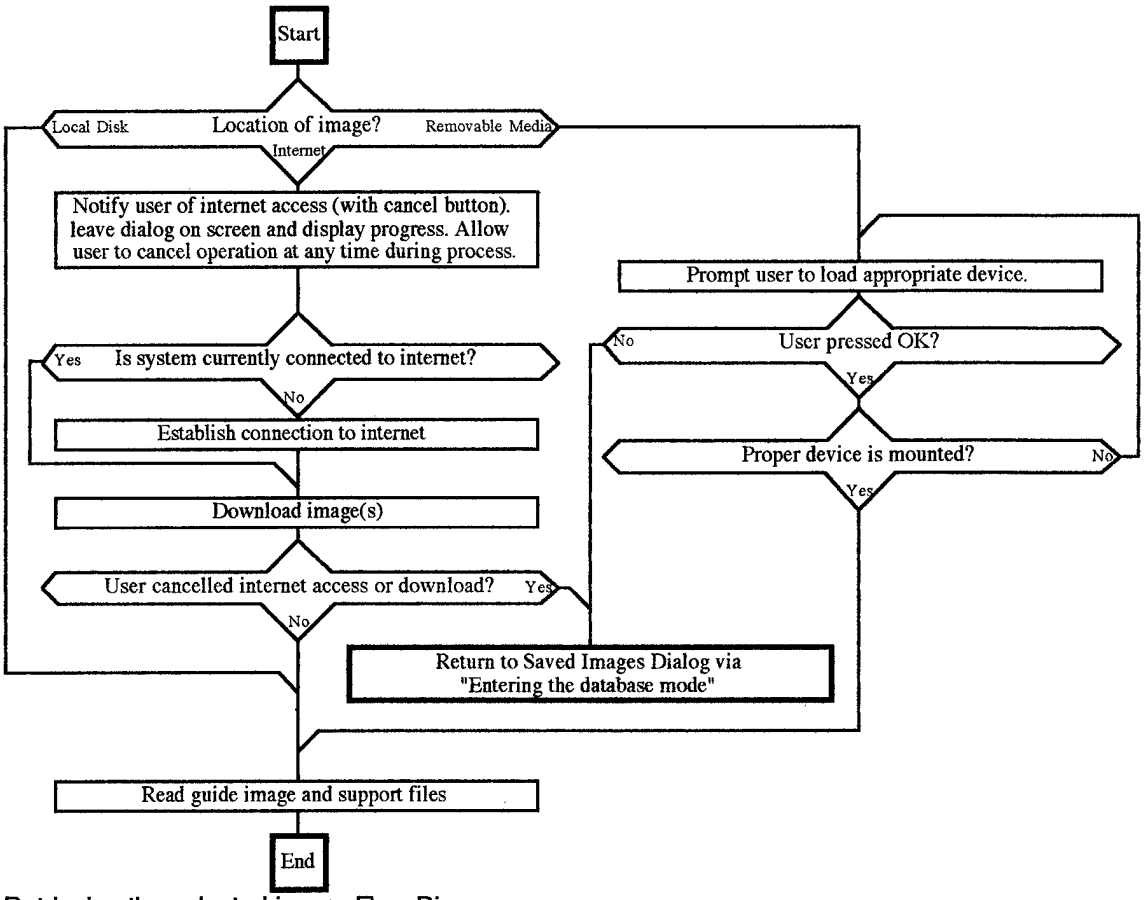
Chat Flow Diagram

3.9 Single Station - Database Mode

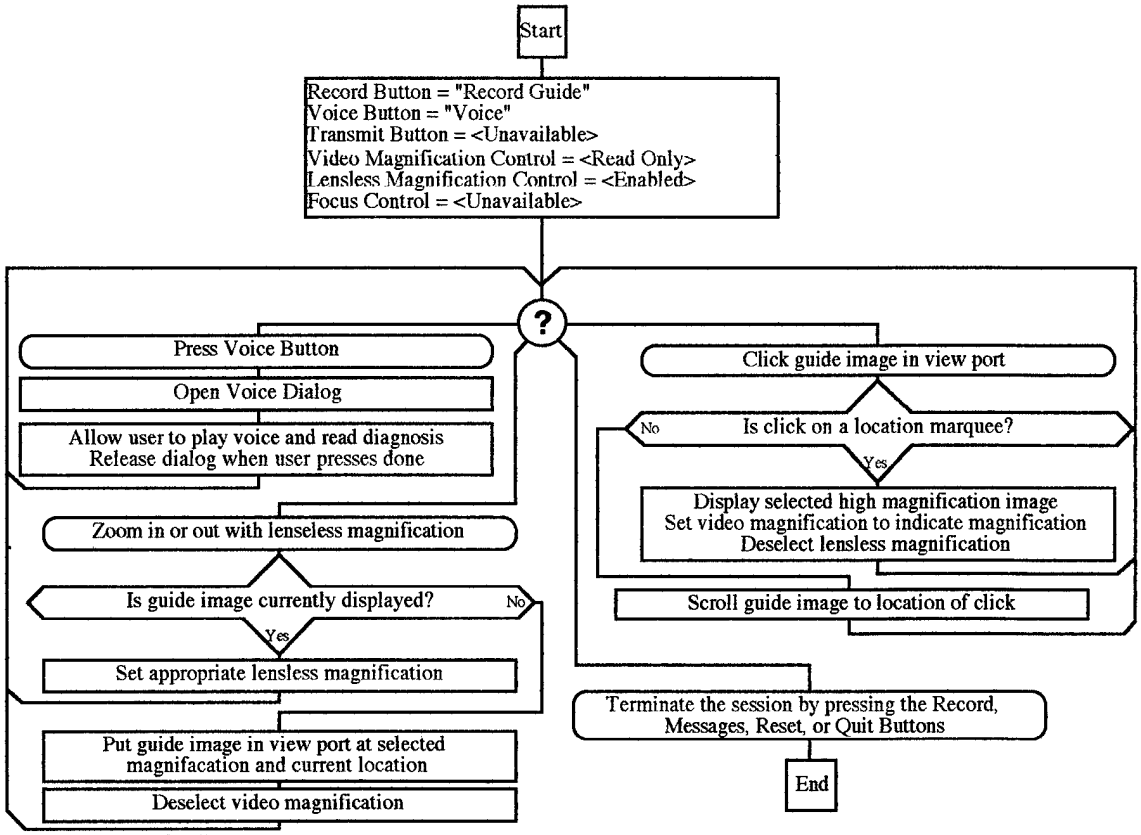
By pressing the database button the user will be given a screen in which to enter search criteria. If no criteria is entered then all available images will be retrieved. The user can enter any of the standard SQL (Structured Query Language) wildcards for search criteria. After entering the criteria and initiating the search the user will be taken to the saved images dialog and allowed to select from the guide images found for that query. Choosing a guide image will return the user to the main window in database mode.



Entering the database mode Flow Diagram

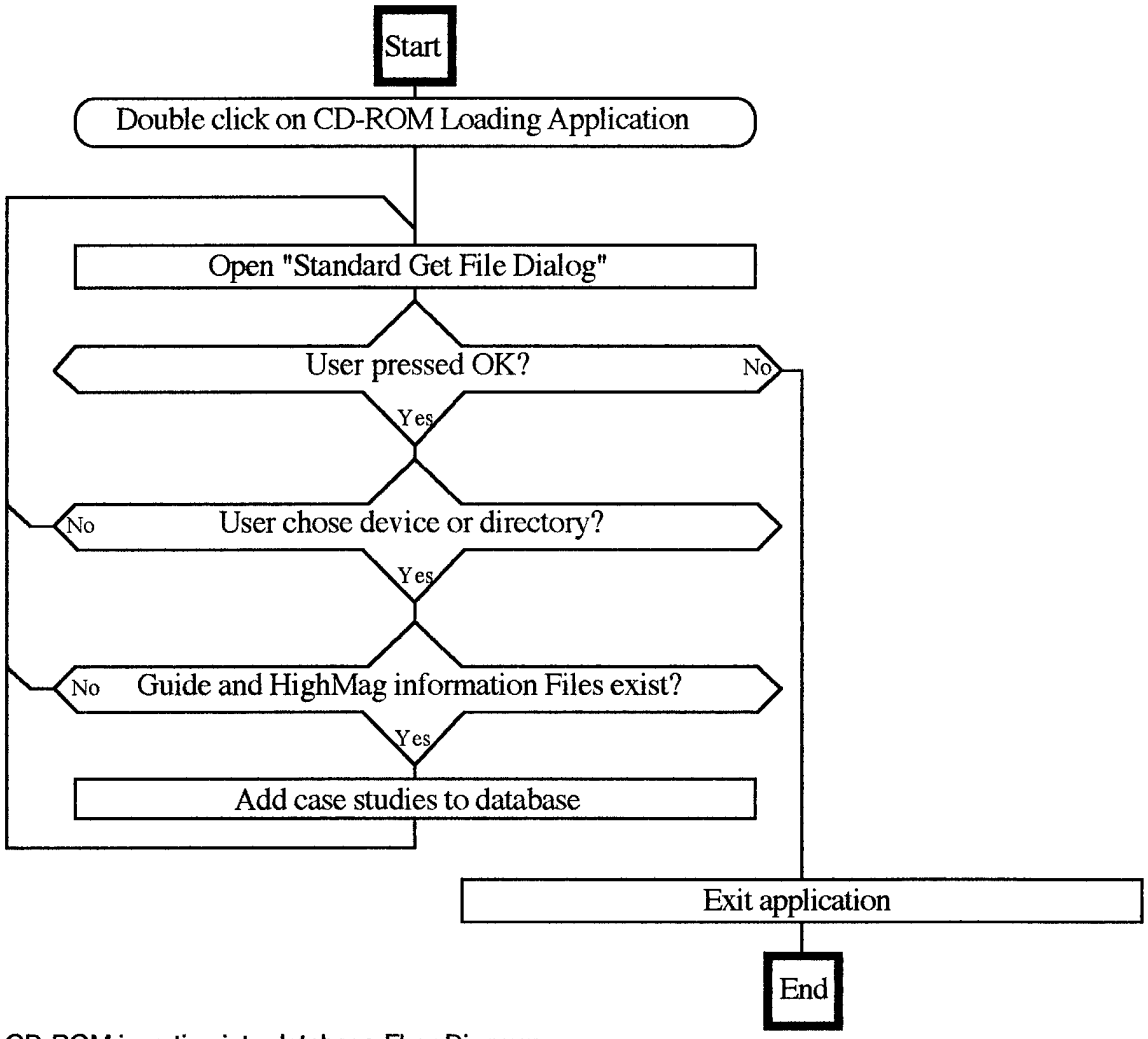


Retrieving the selected image Flow Diagram



Database Mode Flow Diagram

The Tele-Pathology Workstation will ship with a set of CD-ROM's containing public domain case studies which have been already incorporated into the database. Occasionally the user may be in a position to incorporate new CD-ROM's. In order to achieve this task the user will launch a utility application which facilitate the addition of new case studies into the database. The following flow diagram illustrates this procedure.



CD-ROM insertion into database Flow Diagram

In addition to inserting new removable media into the database the user will also need to move completed cases to removable media as the local hard disk fills up. The following flow diagram illustrates this task.

Moving the completed cases to removable media Flow Diagram

4 OBJECT IDENTIFICATION

The following C++ class objects have been identified as needed objects for the execution of the Tele-Pathology Workstation system. Each of the objects is defined in as much detail as is possible at the current time.

4.1 Naming Conventions

The following naming conventions apply to all members and methods in the Tele-Pathology Workstation project. All rules established in the Kensal C++ Coding Standards will apply where not specified.

Member Prefixes:

The prefix will denote the storage method of the member.

Type	Prefix
Handles	hnd
Pointers	ptr
Structures	its

Member Suffixes:

The suffix will denote the usage type of the member.

Type	Suffix
Buttons	Btn
Popup Menus	PU
Static Text	TX
Edit Text	TE
Field Text	TF
Tables/Lists	Tbl
Radio Buttons	Rad
Check Boxes	CBx

For a complete listing of all classes and their definitions see the TPW project code header files.

4.2 Object Summary

Object	Parent	Description
Kensal Foundation Class:		
KFCApp	CApp	A generic application object.
KFCBlockSmooth	NA	An object for performing JPEG block smoothing
KFCButton	CButton	A multi-purpose button which allows different special effects.
KFCColor	KFCServices	An abstract color services classes which is functionally derived by several service objects.
KFCColorGrayRGBtoYCC	KFCColorRGBtoYCC	A service object for Grayscale RGB to YCbCr colorspace conversion.
KFCColorGStoYCC	KFCColorYCCtoYCC	A service object for Grayscale to YCbCr colorspace conversion.
KFCColorRGBtoYCC	KFCColor	A service object for RGB to YCbCr colorspace conversion.
KFCColorYCCtoGS	KFCColorYCCtoYCC	A service object for YCbCr to Grayscale colorspace conversion.
KFCColorYCCtoRGB	KFCColor	A service object for YCbCr to RGB colorspace conversion.
KFCColorYCCtoYCC	KFCColor	A service object for No colorspace conversion.
KFCCommFTP	KFCCommInternet	A communication object for accessing the internet via FTP.
KFCCommHTTP	KFCCommInternet	A communication object for accessing the internet via HTTP.
KFCCommInternet	KFCCommunication	A communication object for accessing the internet.
KFCCommunication	NA	The virtual communication class.
KFCConfirm3StateDlg	CDialogDirector	A dialog box which will return one of three possible results (-1, 0, 1).
KFCConfirmDlg	CDialogDirector	A dialog box which will return one of two possible results (0, 1).
KFCConfirmListDlg	CDialogDirector	A dialog box which takes a pointer to a KFCStringList object and allows the user to select an item. The dialog returns the item number selected or 0 if cancelled.
KFCDebug	NA	A file containing helpful debugging routines (not an object).
KFCDesktop	CDesktop	A desktop object for floating window click sensing and menu bar hiding.
KFCErrorDlg	CDialogDirector	A dialog box for alerting the user of error conditions.
KFCExpanderBtn	CIconButton	An icon button which remembers the expansion value.
KFCFieldText	CDialogText	A text object for displaying static text in a field (box).
KFCFile	CDataFile	A generic file handler.
KFCFileDicom	KFCFileImage	The entry point for DICOM file management

KFCFileDicomDir	KFCFileDicomObject	An object for supporting the DICOMDIR file.
KFCFileDicomImage	KFCFileDicomObject	A DICOM image object
KFCFileDicomMetadata	KFCFileDicomTagList	A DICOM metadata object in a DICOM file
KFCFileDicomObject	NA	A generic DICOM object (List of Tags)
KFCFileDicomObjectList	CVoidPtrArray	A list of DICOM objects
KFCFileDicomTag	NA	A generic DICOM tag
KFCFileDicomTagImage	KFCFileDicomTag	A DICOM image tag
KFCFileDicomTagImplicit	KFCFileDicomTag	An implicit DICOM tag
KFCFileDicomTagList	CVoidPtrArray	A list of DICOM tags
KFCFileDicomTagSequence	KFCFileDicomTag	A DICOM tag sequence
KFCFileDicomTagSequenceItem	KFCFileDicomTagSequence	A DICOM tag sequence item
KFCFileGIF	KFCFileImage	A robust GIF file manager.
KFCFileGIFImage	N/A	A GIF Image in a GIF file.
KFCFileGIFImageList	CVoidPtrArray	A list of GIF Images derived as CPtrArray<KFCFileGIFImage>.
KFCFileImage	KFCFile	A generic image file handler.
KFCFileJPEG	KFCFileImage	A robust JPEG file manager.
KFCFileJPEGImage	N/A	A JPEG Image in a JPEG file.
KFCFileJPEGImageList	CVoidPtrArray	A list of JPEG Images derived as CPtrArray<KFCFileJPEGImage>.
KFCFileQuickTime	KFCFileSound	A sound file class for working with quicktime files.
KFCFileSound	KFCFile	A format free sound file class.
KFCFileTIFF	KFCFileImage	A robust TIFF file manager.
KFCFileTIFFImage	N/A	A TIFF Image in a TIFF file.
KFCFileTIFFImageList	CVoidPtrArray	A list of TIFF images within one file derived as CPtrArray<KFCFileTIFFTagList >.
KFCFileTIFFTag	N/A	A TIFF Tag member of the TIFF file.
KFCFileWave	KFCFileSound	A wave file management object
KFCFlexiblePICTGrid	CPICTGrid	A PICT grid with customizable selection mechanisms.
KFCGlobs	N/A	An object for providing some static functions and global variable initialization.
KFCGridScroll	CScrollPane	A scroll bar for scrolling according to a pre-defined grid dimension.
KFCHuffman	KFCServices	An abstract huffman object
KFCHuffmanDecode	KFCHuffman	An object for decoding huffman data
KFCHuffmanEncode	KFCHuffman	An object for encoding huffman data
KFCIdleChores	CChore	A class for portioning out time to tasks at idle time.
KFCImage	N/A	A virtual class for image management.
KFCImageDims	N/A	An object for storiing a standardized image description.

KFCImageGWorld	KFCImageHead	A GWorld object derived as KFCImageHead<GWorldPtr>.
KFCImageList	CVoidPtrArray	A list of images used by the KFCFlexiblePICTGrid.
KFCImagePane	CPanorama	An object which allows any kind of an image to be displayed and sense clicks and scroll.
KFCImagePICT	KFCImageHead	A PICT object derived as KFCImageHead<PicHandle>.
KFCImagePixMap	KFCImageHead	A PixMap object derived as KFCImageHead<PixMapPtr>.
KFCJPEGPipe	NA	A generic JPEG controller
KFCJPEGPipeComplex	KFCJPEGPipe	A JPEG controller for handling multiple pass coding
KFCJPEGPipeComplexEntropy	KFCJPEGPipeComplex	A JPEG controller for entropy multiple pass coding
KFCJPEGPipeEntropy	KFCJPEGPipe	A JPEG controller of entropy single pass coding
KFCMCU	KFCServices	An abstract object for performing Discrete Cosine Transforms.
KFCMCUExtract	KFCMCU	A DCT Extraction and quantization object.
KFCMCUInsert	KFCMCU	A DCT disassembler object.
KFCMCUInsertInterleaved	KFCMCUInsert	An interleaved DCT disassembler.
KFCNetwork	N/A	An object which connections to a network.
KFCPasswordText	CDialogText	A text object for entering passwords (the input characters are masked).
KFCProgressBar	CRectOvalButton	A progress bar object.
KFCPtrArray	CPtrArray	An array template to provide a few more features than CPtrArray.
KFCQuantizer	KFCServices	An abstract object for performing color quantization services.
KFCQuantizer1Pass	KFCQuantizer	A single pass quantizer.
KFCQuantizer1Pass3Color	KFCQuantizer1Pass	A single pass quantizer for RGB images
KFCQuantizer1PassDither	KFCQuantizer1Pass	A single pass quantizer for dithered images
KFCQuantizer2Pass	KFCQuantizer	A double pass quantizer.
KFCSample	KFCServices	An abstract color sampling service object.
KFCSampleDn	KFCSample	A down sampling object
KFCSampleDnFull	KFCSampleDn	A full down sampling object
KFCSampleDnFullSmooth	KFCSampleDnFull	A full down sampling object that performs smoothing.
KFCSampleDnH2V1	KFCSampleDn	A 2:1 horizontal and 1:1 vertical down sampling object.
KFCSampleDnH2V2	KFCSampleDn	A 2:1 horizontal and 2:1 vertical down sampling object.

KFCSampleDnH2V2Smooth	KFCSampleDnH2V2	A 2:1 horizontal and 2:1 vertical down sampling object with smoothing.
KFCSampleDnInt	KFCSampleDn	An arbitrary integral down sampling object.
KFCSampleUp	KFCSample	An up sampling object
KFCSampleUpFull	KFCSampleUp	A full up sampling object
KFCSampleUpH2V1	KFCSampleUp	A 2:1 horizontal and 1:1 vertical up sampling object.
KFCSampleUpH2V2	KFCSampleUp	A 2:1 horizontal and 2:1 vertical up sampling object.
KFCSampleUpInt	KFCSampleUp	An arbitrary integral up sampling object.
KFCServices	N/A	The base class of the service objects.
KFCSlider	CSubViewDisplayer	A generic slider control.
KFCSliderBar	CPictureButton	The buttons in the slider.
KFCSliderBtn	CIconButton	The bar in the slider.
KFCSliderTE	CDialogText	The active text box associated with a slider bar.
KFCSliderTX	CStaticText	The inactive text box associated with a slider bar.
KFCSliderThumb	CIconButton	The thumb in the slider.
KFCTable	CArrayPane	A table which allows command/item associations and colored items.
KFCTask	N/A	A virtual task class.
KFCTaskList	CVoidPtrArray	A list of tasks.
KFCTaskProg	KFCTask	A generic progress task. This class does not do any drawing.
KFCTaskRdComm	KFCTask	A communication task class for reading from a remote location into a local file.
KFCTaskSound	KFCTask	A task object for playing sound objects.
KFCGenericString	N/A	An object for providing some static string functions.
KFCUtitlities	N/A	Some generic and useful static functions.

Tele-Pathology Workstation Classes:

TPWAddressArrayPane	CArrayPane	An object for displaying the addresses list.
TPWAddresses	CVoidPtrArray	An object for holding an array of address entries.
TPWAddressEntry	NA	An individual address.
TPWApp	CApplication	Handle all command parsing and switching. Perform global instance management.

TPWConnectionsDlg	CDialogDirector	Used to enter connections information for the valid addresses in the transmit dialog.
TPWDatabase	N/A	A Database interface object.
TPWDatabaseQuery	N/A	The object which remembers and manages the users queries on the database.
TPWDatabaseSchema	N/A	An object which is responsible for the creation of the entire database structure.
TPWDBEnterDlg	CDialogDirector	For gathering image data on diagnosis.
TPWDBImagesDlg	CDialogDirector	Handles all file retrieval for viewing of saved images. Is also responsible for displaying thumbnail images on screen.
TPWDBSearchDlg	CDialogDirector	For entering database search criteria.
TPWFocus	CDialogDirector	The focus control for the TPW camera.
TPWGuideFWind	CFloatDirector	Displays the current region of interest during high magnification image creation at 20x.
TPWHelpDlg	CDialogDirector	The help dialog for the TPW.
TPWIdleChore	CChore	A class for portioning out time to tasks at idle time.
TPWImageDataFWind	CFloatDirector	A display of the image data in the current record.
TPWImagePort	KFCImagePane	The view port will handle displaying of the images as well as sensing mouse clicks and performing pan and scroll with the slide table.
TPWLoginDlg	CDialogDirector	The main login dialog at startup in a multiple user environment.
TPWMagGuide	CSubViewDisplayer	Handles all software magnifications of the guide image.
TPWMagVideo	CSubViewDisplayer	Performs all hardware high magnification magnifications as well as indicating the current magnification factor. Also indicates and receives the users location magnification request.
TPWMainWind	CDocument	All functions are initiated and handled through the Main Window. This object is responsible for setting the screen objects and switching to the appropriate methods for actions chosen by the user.
TPWMessagesDlg	CDialogDirector	Remote Users Messages Dialog.
TPWOverlay	CSubViewDisplayer	To change the overlay display.
TPWOverlayData	N/A	An object used to describe an individual high magnification image region.

TPWOverlayList	CSubViewDisplayer	A List of TPWOverlayData Objects.
TPWPreferencesDlg	CDialogDirector	Preferences setting dialog.
TPWSplash	CDialogDirector	The Splash screen which is displayed on screen briefly during launch.
TPWTaskProg	KFCTaskProg	The progress bar drawing class.
TPWTaskRdImage	KFCTask	The image file reading class which draws to the image port.
TPWTaskVoiceDlg	KFCTask	An object for updating progress information and button status during voice play.
TPWThumbnail	KFCImageGWorld	The object responsible for managing a thumbnail in the guide mosaic.
TPWTransmitDlg	CDialogDirector	Gathers the recipients address and sends the request to TPWCommunication.
TPWVoiceDlg	CDialogDirector	Performs all sound manipulation tasks. Is also responsible for attaining diagnosis transcription.

RC/21 Objects:

BADObject	RCObject
BRANCH	N/A
BTree	N/A
BTREE_CURSOR	N/A
B_POSITION	N/A
Column	RCObject
Database	RCObject
DBVALUE	N/A
DCE	N/A
Dictionary	N/A
DTE	N/A
Fieldmap	N/A
FIELDPAGE	N/A
FILTER	N/A
FilterSearchObject	SearchObject
IMPT	RCObject
IMPTE	N/A
IosTie	N/A
IosUnitbuf	N/A
NAME_ENTRY	N/A
NECESSARY_RELATION	N/A
RCObject	N/A
SearchObject	RCObject
streamoff	N/A
streampos	N/A
Table	RCObject
TASK	N/A
TOKEN	N/A
VALDESC	N/A
VALUE	N/A

RC/21 Add-in Classes:

RCColumnBLOB	Column	An object for implementing the movement of PixMap data into and out of the BLOB column.
RCSerialDatabase	Database	For implementation of the serialized database.
RCSerialTable	Table	For implementation of the serialized table.

TPW Database Importer Classes:

TPDApp	CApplication	The importer application class.
TPDImportInternet	N/A	The object responsible for importing internet information.
TPDImportLocal	N/A	The object responsible for importing local information.
TPDiNetPrefs	CDialogDirector	The Internet importing preferences dialog.
TPDMain	CSaver	An object to provide a main interface derived from CSaver<CCollaborator>.

5 FILE FORMATS

The following outlines the basic usage of each file type and generally outlines the proposed file format.

5.1 Session Specific Files

The following outlines all of the possible file formats during a slide analysis session. A session is distinguishable as a slide number. Since each of the sessions have separate slide numbers and all session specific files for a given slide number are stored in a directory which has the same name as the slide number, it is not necessary to put the slide number in the file names.

The session analysis scenarios have been sub-divided into two major categories: DICOM and non-DICOM sessions. Although it is not foreseen at this time that the application will support non-DICOM analyses it is nevertheless mentioned due to it's previous design and current existence within the TPW application. Several of the TPW session specific files can be used in either scenario with equal functionality. These common files can be found at the end of this section. Each of the file names which utilizes a file name extension will implement the extension to indicate the files data type. In several cases the data type has many possibilities. Wherever the data type of the file is flexible the options will be noted. In the File Format sections the identification of a tab character is seen as a "<T>" and a return character as a "<R>."

5.1.1 DICOM analyses

The primary distinction in a DICOM analysis session is the presence of the DICOMDIR file. This file will be present at a root directory location and available for all DICOM analysis sessions. In a given session the image files will be contained in a single directory which has the same name as the slide number.

5.1.1.1 Guide Image

The guide image file stores the guide image only. This file will be typically stored as JPEG compressed data but may optionally be 24 or 15 bit RGB data. The guide image will contain all of the guide specific data needed to position the image within a slide representation and scale the image appropriately. See the Image Labs "Kensal DICOM File Specifications" for further discussion of the necessary tags and layout of this file. In order to accommodate a rapid full screen display of the image during the retrieval of the session it will also be necessary to store a 500x1000 thumbnail of the guide in the same directory. It is not necessary however to store the patient and excession information in this thumbnail as it will all be contained in the guide. The "DICOMDIR" file will contain all of the appropriate file names in the DICOM scenario.

File Name:

"00000000"

File Type:

Tag formatted DICOM.

5.1.1.2 High Magnification Image

The high magnification images will also contain the pertinent tags for there proper placement and scaling. The "DICOMDIR" file will contain all of the appropriate file names in the DICOM scenario.

File Name:

"00000001"

Examples:

"00000001" High magnification image at region 1
"00000002" High magnification image at region 2

File Type:
Each high magnification image will be stored by itself in a DICOM file. Their will be one file for each location where a high magnification picture was taken.

5.1.2 Non-DICOM analyses

5.1.2.1 Guide Image

The guide image file stores guide images, the thumbnail image and any color lookup tables which will be necessary.

File Name:
"GUIDE.TIF"

File Type:
The guide image file will contain both the scanned guide image at 10x and the thumbnail image reduced to 256x128. Each image will be saved in Tiff Compressed format. The file header will contain adequate information for their retrieval.

5.1.2.2 High Magnification Image

File Name:
"HM" + *location num.* + ".TIF"
Examples:
HM01.TIF High magnification image at region 1
HM02.TIF High magnification image at region 2

File Type:
Each high magnification image will be stored by itself in a Tiff Compressed file. Their will be one file for each location where a high magnification picture was taken. The location and magnification of the image can be reconciled through the regions file.

5.1.2.3 Image Data

Each image will have an associated line in the data file. The Slide number, Start Date, and Finish Date are stored automatically. The purpose of the data files is to perform similar services as those of the DICOMDIR file.

File Name:
"GD.TXT" / "HM.TXT"

File Type:
Image data is stored in a text file in tab delimited format.

File Format:

"GD.TXT"	"HM.TXT"
Folder<T>	Slide_No<T>
Slide_No<T>	Prefix<T>
Prefix<T>	Suffix<T>
Suffix<T>	Stain<T>
Stain<T>	Record_Dt<T>
Start_Dt<T>	Record_Tm<T>
Finish_Dt<T>	Sequence<T>
MD_LName<T>	Magnification<T>

MD_FName<T>
MD_MName<T>
Institution_Name<T>
Institution_City<T>
Institution_State<T>
Topography<T>
Morphology<T>
Etiology<T>
Function<T>
Disease<T>
Procedure<T>
Occupation<T>
Snomed<T>
Scale<T>
XOffset<T>
YOffset<T>
Technician_LName<T>
Technician_FName<T>
Technician_MName<T>
Media<R>

Scale<T>
XPosition<T>
XPosition<T>
Technician_LName<T>
Technician_FName<T>
Technician_MName

5.1.3 Regions

File Name:

"REGIONS.TXT"

File Type:

The regions file contains a comprehensive list of all location/magnifications visited, requested and saved during the entire session. The file is a simple text file in tab delimited format. The format is given below. The identifier column identifies the action (V = Visit, R = Request, S = Saved). The X and Y locations are in micro meters. The location number indicates the sequence in which the events occur. Notice that visits get decremented while requests and saves get incremented.

File Format:

Header:

TPW version<T>Slide No.<T> Guide Offset (Microns) Hor.<T> Vert.<R>

Detail:

Identifier<T>
Location Number<T>
Magnification<T>
X Location<T>
Y Location<T>
Date and Time<T>
User<R>

File Example:

Note - This is not a real life example.

1.10		12345	0	0		
V	-1	200	34288	20898	95.09.13-13:43	Smith@Mayo
R	1	400	5543	5432	95.11.13-15:43	Smith@Mayo
S	1	100	876	9965	95.11.14-09:43	Smith@Mayo

5.1.4 Voice

The voice file stores a single digitized voice. Since the same location can record voice from both the local and remote user and the slide examination session can span multiple iterations it becomes necessary to be able to delineate the files. The voice file can be saved as either a Quicktime file (.MOV) or a Wave file (.WAV)

File Name:

["GD_" | "HM" + *location* + "_"] + [*user* ("L" | "R") + iteration | "DG"] + ".XXX"

Examples:

GD_R01.WAV The remote users 1st iteration for the guide image

HM08_L02.MOV The local users 2nd iteration for the high magnification image at region 8

GD_DG.WAV The pathologists diagnosis for the guide image

HM02_DG.MOV The pathologists diagnosis for the high magnification at region 2

File Type:

This is a standard QuickTime™ of Microsoft Wave file storing simply the digitized voice.

5.1.6 Diagnosis

File Name:

"DIAGNOS.TXT"

File Type:

The diagnosis file will contain a transcribed version of each voice file given during the transcription mode.

File Format:

Diagnosis Text (with optional embedded carriage returns) <R>
["Region" + space + region # + ":" < Return >
Region Specific Diagnosis Text (with optional embedded carriage returns) <R>]
[more locations...]

File Example:

Some text which is associated with the entire slide analysis session.

Possibly with some embedded return characters.

Region 7:
The above string will flag the TPW that this text is associated with a specific location, in this case location number 7.

Region 12:
The file can contain as many locations as necessary but should only include each location once.

5.2 Global Files

5.2.1 Messages

The information in the messages file will be tab/return delimited. Messages will be indicated by a code: A = Analysis Requested, L = Image Locations Requested, I = Images Received, D = Diagnosis Received. An asterisk will indicate that the message has been paused. An entry for the resolution will indicate that the message has been addressed.

File Name:

TPW_Messages

File Type:

A standard text file will hold all of the messages for a predetermined period of time. An archive of messages files will be kept indefinitely.

File Format:

Message type & pause indicator<T>
Date and Time Received<T>
Sender<T>
Receiver<T>
Resolution Date and Time<R>

File Example:

A	95.09.23-12:14	Jones@Mayo	Warner@J.Hopkins	95.09.23-14:11
L*	95.09.23-13:33	Smith@PCH	Hanks@J.Hopkins	
I	95.09.23-13:33	Jones@Mayo	Warner@J.Hopkins	

5.2.2 Addresses

The addresses file contains all of the saved addresses for the system. Each entry will contain an identifier as to its base connection type (either D or F for Direct or FTP respectively) and will be followed by the appropriate information according to the connection profile. At present the only connection profile identified is Direct over ISDN. As more connection profiles are incorporated a standard format for them will be adopted. If the profile requires a password the password will be encrypted.

File Name:

TPW_Addresses

File Type:

The file is standard text in tab/return delimited format.

File Format:

ISDN:
Connection Name<T>
Connection Type<T>
Hardware<T>
Phone Number<T>
Login<T>
Password<T>
Owner<R>

File Example:

Jones@Mayo	D	ISDN	1-602/555-8877	WarnerJH	^%ï™	Warner
Smith@PCH	D	ISDN	1-602/555-7576	Warner	^ËAÏî	Warner
Erics@Mayo	D	ISDN	1-602/555-8877	HanksJH	ïî‰	Hanks
Timms@PCH	D	ISDN	1-602/555-7576	Hanks	·°‡·	Hanks

5.2.3 Preferences

The preferences file will contain the preference settings as well as the pertinent information to implement the settings. Since the system will be used by multiple users who will log in with a user name the preferences will be user specific if the preferences file indicates multi user (i.e. no login/password stored). The brackets ('[' and ']') indicate the optional syntax if multi user preferences is in use.

File Name:

TPW_Preferences

File Type:

A standard text file.

File Format:

"Mode:" <T>Single|Multi<R>

["Login:" <T>Login Name<R>

"Password :" <T>Password<R>]

"Messages:"<T>Messages Boolean[<Comma>User 1<T>
Messages Boolean<Comma>User 2<T>
... Messages Boolean<Comma>User n]<R>

"Locations:"<T>Number of Windows<T>Locations Boolean[<Comma>User 1<T>
Locations Boolean<Comma>User 2<T>
... Locations Boolean<Comma>User n]<R>

Window 1 Name<T>
Left<Comma>Top<Comma>Right<Comma>Bottom[<Comma>User 1<T>
Left<Comma>Top<Comma>Right<Comma>Bottom<Comma>User 1<T>
... Left<Comma>Top<Comma>Right<Comma>Bottom<Comma>User n]<R>

... Window n Name<T>
Left<Comma>Top<Comma>Right<Comma>Bottom[<Comma>User 1<T>
Left<Comma>Top<Comma>Right<Comma>Bottom<Comma>User 1<T>
... Left<Comma>Top<Comma>Right<Comma>Bottom<Comma>User n]<R>

"Transcriptionist:"<T>Transcriptionist Name[<Comma>User 1<T>
Transcriptionist Name <Comma>User 2<T>
... Transcriptionist Name <Comma>User n]<R>
"LUTs:"
"TC217_1"<T>Channel<T>Threshold<T>Offset<T>Gain<T>Gamma <R>
"TC217_2"<T>Channel<T>Threshold<T>Offset<T>Gain<T>Gamma <R>
"TC217_3"<T>Channel<T>Threshold<T>Offset<T>Gain<T>Gamma <R>
"RL4000P_1"<T>Channel<T>Threshold<T>Offset<T>Gain<T>Gamma <R>
"RL4000P_2"<T>Channel<T>Threshold<T>Offset<T>Gain<T>Gamma <R>

File Example:

Single User:

Mode:	Single
Login:	Jones
Password:	ÏÁÊÂÁÏ
Messages:	TRUE
Locations:	2 TRUE
Guide	35,67,291,323
Data	950,876,1280,1024
Transcriptionist:	Chenry
LUTs:	

TC217_1	1	511	127	14.0	0
TC217_2	1	511	127	14.0	0
TC217_3	1	511	127	14.0	0
RL4000P_1	1	511	127	14.0	0
RL4000P_2	1	511	127	14.0	0

Multi User

Mode:	Multi				
Messages:	TRUE,Warner				FALSE,Hanks
Locations:	2	TRUE,Warner			FALSE,Hanks
Guide	35,67,291,323,Warner				0,0,0,0,Hanks
Data	950,876,1280,1024,Warner				950,5,1280,153,Hanks
Transcriptionist:	CHenry,Warner				PDempsy,Hanks
LUTs:					
TC217_1	1	511	127	14.0	0
TC217_2	1	511	127	14.0	0
TC217_3	1	511	127	14.0	0
RL4000P_1	1	511	127	14.0	0
RL4000P_2	1	511	127	14.0	0

6 ERRORS, WARNINGS, AND MESSAGES

The following section outlines the primary user messages which will occur throughout the use of the system. This is not presented as a comprehensive list of all possible messages as more will undoubtedly be uncovered during the implementation phase. Rather this provides a broad outline of the kinds of anomalous situations in which the user may find themselves. Variables which will be substituted at time of use are shown in braces.

6.1 User Errors

Message	Reference Section
Slide number {slide no} already exists. Please try again.	3.1
Slide number {slide no} is too [short | long]. Please try again.	3.1
Sorry, There is no slide loaded in the microscope.	3.1, 3.3

6.2 System Warnings

Message	Reference Section
The {mode} is incomplete and will be saved as a paused message.	N/A

6.3 General Messages

Message	Reference Section
Before continuing the chat some images need to be transferred. You will be notified once transfer is complete.	3.8

6.4 User Requests

Each request string is given below with the button titles in parentheses. The default button is underlined.

Message	Reference Section
Messages are pending do you want to respond? (Yes, No)	3
Are you sure you want to pause the {mode} from {user}? (Yes, No)	3
Please put slide number {S#} in the microscope and press OK. (Cancel, OK)	3.3
Are you sure you want to terminate the chat with {user}? To pause the chat press the pause button. (Pause, Cancel, OK)	3.8
User {user} would like to chat. Clicking OK will pause your current {mode}. (Cancel, OK)	3.8

7 DATABASE

This section describes the structure and intended function of the Tele-Pathology Workstation database.

7.1 Description

The TPW database has been developed over a core of objects developed by the Vermont Database Corporation. This database core is known as the RC/21 database library. The RC/21 is a full featured relational database with BLOB (Binary Large Object), referential integrity, transaction processing, and other necessary TPW features. In order to customize the RC/21 to suite the TPW several derived object have been developed as can be seen above. In addition, a table is created with each RCSerialDatabase whose purpose is to implement the serial data types.

7.2 Schema

The following section describes the structure of the database as it shall be implemented for the TPW. Additional tables and/or columns may be necessary in the future as need dictates during actual usage.

Data Types:

Serial	An indexed integer column which is set up to automatically increment in value.
Integer	4 byte whole numbers.
String	Alpha numeric information of any length.
Real	8 byte floating point numbers.
Blob	ASCII character data of any size.
Date	Internal integer values stored as the number of days since 1 January 1904.
Time	The time of the day stored in seconds from midnight. A Real value.

Table/Column	Data Type	Description
Images Table:		The images table is designed to hold all guide image specific information. The images table can be seen as the primary table in the database.
image_id	Serial	images table primary key.
device_id	Integer	foreign key to the devices table.
institute_id	Integer	foreign key to the institutes table.
md_id	Integer	foreign key to the MD table.
operator_id	Integer	foreign key to the operators table.
folder	String	folder name of the image and it's associated files (8 characters or less ISO9660).
slide_no	String	7 digit medical slide number.
file_name	String	file name of the image file.
prefix	String	a slide number prefix.
suffix	String	a slide number suffix.
stain	String	a code indicating the stain used on the slide.
start_dt	Date	the date which the guide image was recorded or the case was started.
finish_dt	Date	the date which the case was finished.
topography	String	SNOMED topography code.
morphology	String	SNOMED morphology code.
function	String	SNOMED function code.
etiology	String	SNOMED etiology code.
living_org	String	SNOMED etiology: living organism code.
chem_etc	String	SNOMED etiology: chemicals, etc. code.
phys_agents	String	SNOMED etiology: physical agents code.
occupation	String	SNOMED occupation code.
social	String	SNOMED social context code.
disease	String	SNOMED disease code.
procedure	String	SNOMED procedure code.

general	String	SNOMED general code.
description	String	full text description of the image.
scale	Real	the scale of the image in microns per pixel.
xoffset	Integer	the offset from the label of the slide to the center of the image in microns (slide label held in right hand).
yoffset	Integer	the offset from the top of the slide to the center of the image in microns (slide label held in right hand).
thumbnail	Blob	thumbnail stored as a flattened PixMap (256x128).
results_name	String	file name of the results file.
Devices Table:		All of the individual devices which are recognized by the system will have an entry in the devices table. This makes it quite simple in the future to implement such features and CD-ROM burning utilities.
device_id	Serial	devices table primary key.
media_type	Integer	a 4 character mnemonic indicating the type of the media ('cdrm', 'locl', 'inet', ...).
name	String	the short name of the device.
path	String	the full path of the device.
create_dt	Integer	the date of device as applicable.
icon	Blob	an icon representing the device. Stored as a CIcon.
Institutes Table:		General information about the medical institution which originates the slides. This is not meant to be a comprehensive detailing of the institute.
institute_id	Serial	institutes table primary key.
name	String	institutes full name.
address	String	1st address line.
address_opt	String	2nd address line (suite no., bldg. no., etc.).
city	String	full city name.
state	String	2 character state abbreviation.
zip	String	postal code.
country	String	full country name (if blank USA assumed).
MD Table:		Information about the professionals who are primarily responsible for the diagnosis of the slides.
md_id	Serial	MD's table primary key.
fname	String	given name of MD
mname	String	initials of MD
lname	String	surname of MD
salutation	String	appropriate leading salutation (Mr., Mrs., Ms., etc.).
position	String	applicable position (Physician, Resident, etc.).
title	String	applicable title (President, Chief Resident, etc.).
credentials	String	credentials and entitlements (MD, D.D.E., etc.).
address	String	1st address line.

address_opt	String	2nd address line (suite no., bldg. no., etc.).
city	String	full city name.
state	String	2 character state abbreviation.
zip	String	postal code.
country	String	full country name (if blank USA assumed).
Operators Table:		Information about the individuals who are responsible for image recording.
operator_id	Serial	operator tables primary key.
fname	String	given name of operator.
mname	String	initials of operator.
lname	String	surname of operator.
HighMags Table:		A table for the storage of the high magnification image logistical data.
highmag_id	Serial	highmag tables primary key.
image_id (1)	Integer	foreign key to images table.
file_name	String	file name of the image file.
sequence (1)	Integer	highmag image sequence within the guide images set of highmags.
record_dt	Date	date of recording the image.
record_tm	Time	time of recording the image.
magnification	Integer	ocular magnification of recording.
scale	Real	the scale of the image in microns per pixel.
xposition	Integer	horizontal position of the center point of the image with respect to the guide image in microns.
yposition	Integer	vertical position of the center point of the image with respect to the guide image in microns.
width	Integer	height of the image in pixels.
height	Integer	width of the image in pixels.

Glossary of Terms

Enabled - A control or screen object which is capable of being manipulated by the user.

Disabled - A control or screen object which is incapable of being manipulated by the user but which is still visible. The visibility will undoubtedly be in some sense indicating that the object is inaccessible.

Unavailable - A control or screen object which is not visible to the user and is further not functional.

Mode - A description of the users operation capabilities according the work that the user is attempting to perform.

Scenario - A description of a typical task that the user might wish to perform. A Scenario will often times be comprised of many Modes.

Flow Diagram - A scenario in graphical terms.

Schema - A description of a databases structure at the table, column and relationship level

Table - A database entity of primary concern. A place to hold rows of information pertaining to the same subject.

Column - A single definable database table attribute.

Row - A database entity instantiation.

Relationship - A defined "joining" of database entities.

APPENDIX C

RAW DATA
FROM
1996 LUKE/MAYO TELEPATHOLOGY STUDY

Slide	Source	Diagnosis from Workstation Images	Actual Diagnosis from Patient Files	Diagnosis from?	AOI's requested
501000	Mayo	High grade dysplasia, carcinoma insitu	Epidermoid carcinoma in situ (Bowen's Disease)	5th high mag (20x)	10
502000	Mayo	Immunoperoxidase stain needed for diagnosis;	Metastatic adenocarcinoma	N/A	27
		(guessing melanoma or undifferentiated carcinoma)			
503000	Mayo	No diagnosis given	Inverting epithelial papilloma (sino-nasal type)	N/A	8
503100	Mayo	Benign neoplasm, probably an inverted papilloma	Inverting epithelial papilloma	7th high mag (20x)	10
504000	Mayo	Malignant lymphoma	Malignant Lymphoma	9th high mag (40x)	13
504100	Mayo	Same as previous case	Same as previous case	No diagnosis given	8
505000	Mayo	Medication induced "black thyroid"	"Black thyroid"	7th location (40x)	7
505100	Mayo	Black thyroid due to treatment with monocycline	"Black thyroid"	13th location (40x)	15
506000	Mayo	Carcinoid tumor	Atypical bronchial carcinoid tumor	28th location (20x)	35
506100	Mayo	Carcinoid tumor	Atypical bronchial carcinoid tumor	4th location (4x)	21
506200	Mayo	Bronchial carcinoid tumor	Atypical bronchial carcinoid tumor	12th location (20x)	21
507000	Mayo	Intracystic (intraductal) adenocarcinoma, low grade	Intracystic papillary carcinoma	15th location (40x)	16
507100	Mayo	Neuroendocrine differentiation suggested, no diagnosis given	Intracystic papillary carcinoma	9th location (10x)	19
507200	Mayo	Intracystic (intraductal) well differentiated adenocarcinoma of ductal origin	Intracystic papillary carcinoma	16th location (40x)	16
508000	Mayo	Hepatatic capsular hamartoma (multiple)	Hamartomatous capsular scar	30th location (20x)	34
509000	Mayo	Lobular carcinoma insitu	Multifocal lobular carcinoma in situ	32nd location (10x)	33
510000	Mayo	(Only a Scout Image in this file; no voice files)	Alveolar Proteinosis	N/A	0
511000	Mayo	Primary biliary cirrhosis, Stage 3	Chronic Hepatitis (Syndrome of primary biliary cirrhosis, Stage 3)	29th location (20x)	29
512000	Mayo	Benign lyomyoma with nuclear atypia	Bizarre Atypical Leiomyoma	18th location (20x)	20
513000	Mayo	Lobular carcinoma insitu, superimposed on pre-existing lesion of fibroadenoma	Lobular carcinoma in situ arising in a fibroadenoma	19th location (20x)	25
514000	Mayo	Lymphangiomyomatosis	Lymphangiomyomatosis	11th location (20x)	12
515000	Mayo	Venus outflow obstruction and secondary massive zonal necrosis	Venus outflow obstruction with zonal necrosis	13th location (40x)	13
516000	Mayo	Granulosa cell tumor of the ovary	Granulosa Cell Tumor	16th location	16
517000	Mayo	Epithelioid endothelium	Epithelioid Hemangioendothelioma	20th location	20
518000	Mayo	Cirrhosis secondary to alpha-1 antitrypsin	Cirrhosis with hemosiderosis secondary to alpha-1 antitrypsin deficiency	16th location	16
519100	Mayo	Benign adenofibromena cytoplasia	Benign Fibroglandular Prostatic tissue	34th location	34
520000	Mayo	Subacute and chronic prostatitis	Chronic Prostatitis, nagative for malignancy	28th location	29
601000	Luke	Fibroadenoma	Fibroadenoma	40th location (40x)	40
602000	Luke	Benign lesion; fibrocystic change of the breast	Fibrocystic change	9th location (10x)	11
603000	Luke	Adenomatus nodule	Adenomatous nodule	11th location (20x)	11
609000	Luke	Seborrhoid keratosis, inflamed	Seborrheic keratosis	7th location (no mag)	7
610000	Luke	Dermatomycosis	Dermal fibrosis	5th location (40x)	5
611000	Luke	Hemorrhoids	Anorectal polyp	6th location (no mag)	6
612000	Luke	Ovarian stromal cell tumor fibroma	Ovarian tumor	8th location (10x)	8
613000	Luke	Follicular carcinoma	?	6th location (no mag)	6
614000	Luke	Malignant melanoma	Malignant melanoma	16th location (no mag)	16
615000	Luke	Adenoma	Nodular sclerosing adenosis	6th location (no mag)	6
616000	Luke	Reactive lymphoid hyperplasia	Lymphoid reactive folicular hyperplasia	7th location (no mag)	7
617000	Luke	Occifying Fibroma (Epulis)	Epulis hyperplasia (gingival mass in canine specimen)	14th location (40x)	14
618000	Luke	Well differentiated prostatic adenocarcinoma, grade 1	Prostatic adenocarcinoma	8th location	8
619000	Luke	Occifying fibroma, epulis	Epulis hyperplasia (canine specimen)	9th location	9
620000	Luke	Fat necrosis of a reaction to a foreign body (i.e. silicone)	?	6th loction	